MANAGING TO START:

THE APPLICATION OF LEAN STARTUP AND

DESIGN THINKING TO ACADEMIC

COMMERCIALISATION PROJECTS

BY

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Abstract

This thesis examines the application of Lean Startup and Design Thinking processes to the commercialisation of academic research. Using retrospective analysis of project work undertaken by the "Hyv" team as part of the 2013 Masters of Advanced Technology Enterprise (MATE) programme, it is demonstrated that both Lean Startup and Design Thinking provide useful frameworks for research commercialisation by interdisciplinary academic teams. The Lean Startup provides a framework within which to test key assumptions about a project while building towards a sustainable business model. This proved particularly relevant as the team explored preconceived commercialisation paths for ongoing research projects. In contrast, Design Thinking provides a valuable means of achieving a complete understanding of a problem faced by a particular market, thereby informing the development of a viable solution. The applicability of these two conceptual frameworks to research ideation and commercialisation became evident in response to the requirements of projects analysed during the MATE course (specifically the NacreTech and Sound Concepts projects), and they together provide complementary theoretical bases for future work. Their application to different research projects provided the team with broad experience, both positive and negative, and yielded useful strategies for future commercialisation work. More directly, they provide a means of revising the MATE programme to foster interdisciplinary research commercialisation across the university.

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Thanks to project champions Professor McGrath and Natasha Perkins for allowing a pack of enthusiastic but inexperienced students the opportunity to dive into the commercial potential of your research. I hope we have contributed something useful to your ongoing work.

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Oliver Townend

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Chapter 1 Introduction

The aim of this thesis is to report on and analyse the author's experience of the inaugural Masters of Advanced Technology Enterprise (MATE) program at Victoria University of Wellington. By analysing the MATE experience, with reference to current theory, I aim to suggest processes which might lead to successful commercialisation of advanced technology research in the tertiary sector.

Through the MATE programme the author and an interdisciplinary team (later referred to as "Hyv") worked to find commercial applications for existing research projects from within the university. The team adopted a startup business structure focused on establishing and developing the commercial viability of the projects.

This thesis draws on the author's experience of working with the team while making use of relevant current theory in design thinking and lean product development to examine the progress and outcomes of projects within the course. Owing to the commercial focus of the programme and to its reactive nature, theoretical elements were identified and adopted as the course progressed throughout the year. This reactive characteristic of the MATE programme reflects real world conditions for commercialisation. As a result this thesis has not followed a conventional research model and its structure reflects the gradual accumulation of theory informed by practice.

As this is a new course there are no direct precedents for writing a thesis but the dominant interdisciplinary intent of the course led to the exploration of management, manufacture, design and marketing literature.

The body of this thesis addresses the three main stages of the team's project work, in chronological order:

- Chapter 3: A Lean Startup-influenced approach to commercialisation of existing research projects.
- Chapter 4: A user-centred process of product development using elements of Design Thinking.

- Chapter 5: Discussion of current project status and consideration of future viability.

Chapter 6 provides an analysis of the programme overall and conclusions, focusing on how the MATE course might best make use of Lean Startup and Design Thinking to facilitate entrepreneurship within the framework of a year-long programme of study.

The remainder of this introductory chapter details the key elements of the year's work as delivered in 2013: the MATE course structure, the team, projects and project champions.

1.1 Masters of Advanced Technology Enterprise

The Masters of Advanced Technology Enterprise (MATE) is an interdisciplinary research programme first offered in 2013 and designed to develop potential for commercially viable businesses with foundations in scientific research. Participants adopt a startup business format and establish teams to develop high-value enterprises from existing university research projects with the ultimate goal of creating self sustaining spinout businesses with proven commercial potential.

Following an introductory program, the participants are pitched potential commercialisation projects by "project champions", in each case typically a university academic leading an ongoing research project that has demonstrated undeveloped potential for commercial viability. The MATE participants are provided with information about the research project's development to date and the champion's proposed commercialisation direction. A process of discussion and validation results in the formation of teams who will form the functional core of any resulting commercial entity.

Students are introduced to industry and academic specialists with experience relevant to the development of specific projects. Further, students are provided with resources to experiment, explore options and identify appropriate business models and paths to market.

Due to the interdisciplinary nature of the MATE programme no two participants arrive with exactly the same experience. Participants come from a range of academic backgrounds and work on existing research projects from various schools within the university. Students are therefore unlikely to be working within the discipline in which they originally trained, but will ideally be able to apply elements of their prior experience to the project as a whole.

Team members are expected to utilize their prior education and experience, taking on relevant roles and responsibilities as required. Where essential skills are missing from the teams there is scope to outsource the assistance needed. Given that 2013 was the first year of the course, the team selection process was limited by the small number of students.

By thinking as a business the team is able to set aside academic concerns and concentrate on what will be necessary to take a research project with recognized commercial potential and develop it into a viable business. The project champion, while providing some technical expertise and support, is not a full time member of the commercialisation team.

Importantly, the MATE course provides the participants with a relatively safe environment in which to grow their experience, build contacts, experiment with commercialisation techniques and, more than likely, fail in their early attempts. Given that a high proportion of startup businesses do not succeed, this low-risk experience of identifying constraints and overcoming setbacks should provide MATE graduates with an advantage in future entrepreneurial pursuits and the ability to identify and avoid problematic business plans. In the words of serial entrepreneur Steve Blank: *"It's OK to screw it up if you plan to learn from it"*. (Blank, 2007, p.19)

1.2 Author

Oliver Townend completed a Bachelor of Design (Hons) at Massey University in 2004, majoring in industrial design with a focus on furniture. He entered the residential construction industry in 2005 and completed an apprenticeship as a residential builder through the Building and Construction Industry Training Organisation in 2009.

Oliver Townend Building Limited has operated in the Wellington region since 2009, providing the author with valuable experience of small business practice including project management, customer interaction, staff, accounting and legal practices. This combination of design training, construction knowledge and business experience has provided a broad perspective in approaching the MATE programme.

The author expected to find this experience in project management most applicable to the MATE commercialisation process. It was not expected that industrial design would form a significant component of the year's work. However, the author's design training and focus on physical (rather than digital or scientific) products and processes rapidly became a significant contributing factor in the selection of projects and the role assumed within the team as product development lead.

1.3 Team

- Liam Harker has a background in science and biotechnology. His focus for MATE is in commercialisation strategy and technology assessment.
- Ish Jimale has qualifications in biotechnology, management and international business. His focus is the application of business and management theory to science commercialisation.
- Ian Walsh studied international relations, communications and customer relations. He hopes to develop his experience in communications and business strategy.
- Naomi First has extensive experience in business and consulting for public sector clients, as well as management, marketing and business development.

The development of individual roles within the team will be discussed further in Chapters 3 and 4.

1.4 Projects and Project Champions

During the course of the year, the 2013 MATE students were pitched four potential commercialisation projects. Detailed below are the two that were worked upon by the team.

1.4.1   Nacre

Research by Prof Kate McGrath, VUW

Nacre (commonly known as "mother of pearl") is produced by some molluscs, including oysters and mussels, forming the inner coating of shells and the outer layers of pearls. Professor Kate McGrath has developed a method for the production of a synthetic nacre-like composite material (meaning that it is comprised of two or more components). The structure of this material mimics that of hard tissue (bone) and is non-toxic under in-vitro conditions (McGrath, 2013).

The proposed commercialisation of Professor McGrath's research looks to develop synthetic nacre as an alternative to ceramic and metallic hard tissue implants, for use in orthopaedic surgery. The chemical and structural composition of nacre is sufficiently similar to native hard tissue (bone), that these implants could potentially be accepted by the host to the point of total absorption and assimilation as bone. This enhanced compatibility would lower the chance of rejection and the need for replacement.

The path proposed to the MATE students was the development of an injectable nacre-based gel, for use as a filler in veterinary dentistry to prevent infection following tooth extraction. Working in the animal health sphere would provide a faster path to market than direct entry into human orthopaedics, due to the lower regulatory barriers. Such a product would provide valuable proof of concept and a revenue stream to enable the development of subsequent human applications.

1.4.2   Sound Concepts

Research by Natasha Perkins, VUW

School of Architecture Senior Lecturer Natasha Perkins' ongoing Sound Concepts research project aims to develop and test forms that will aid in reducing reverberation times in interior environments (Perkins, 2013)*.* The current commercial focus of the research, as presented to the MATE students, involves the use of formed polyester panels that are assembled to create baffles and acoustic furniture for use in school classrooms, atriums, community halls and offices. By forming three-dimensional

structures from flat polyester sheet, the research team sought to improve the acoustic performance of the material while creating functional, aesthetically pleasing pieces of furniture. Pitched to the MATE students were a hanging baffle "Triform" and a self-supporting breakout space "Pod" designed for primary school children. Testing had shown that the two concepts provided measurable benefits for internal acoustics. It was proposed that the MATE students would investigate and validate the market by identifying and interviewing potential customers and developing a business model which would include options for production, distribution and sale of the products.

FIGURE 1: TRIFORM HANGING BAFFLE

FIGURE 2: POD CLASSROOM BREAKOUT SPACE

Chapter 2 Theoretical Framework

This section presents the theories that have been most influential to the author in development of the team's projects and in his broader gains from the course. They are presented in the order in which they were identified and utilised over the course of the year.

2.1 Lean Thinking

Lean Thinking is methodology that seeks to provide the greatest possible benefit with the smallest possible effort (Womack and Jones, 1996). Initially developed from the Toyota Production System (Liker, 2004), Lean was popularized in the book *The Machine That Changed the World* (Womack, Jones and Roos, 1990). Toyota's highly successful strategies for coping with limited resources following World War Two (originally an alternative to mass-production as perfected by Henry Ford) lead to widespread adoption of Lean Thinking strategies and derivatives.

What began as a method for improving efficiency in heavy manufacturing companies through careful consideration and reorganization of processes and activities subsequently grew to encompass every aspect of business planning from supply chain to distribution (Liker, 2004). At its core, Lean Thinking is a set of tools for eliminating waste, creating value and improving flow, or, *"creating more value for customers with fewer resources"* (Lean Enterprise Institute, 2009). We define the terms waste, value and flow below.

2.1.1 Waste

In Lean terminology, waste is defined as: "*Any human activity which absorbs resources but creates no value.*" (Womack and Jones, 1996, p.15)

Waste in manufacturing can be anything from the time taken in transportation of parts within a factory, to over-production of unnecessary components. Through Lean Thinking, businesses seek to identify and eliminate these unproductive activities. Womack and Jones define a specific form of waste that is highly relevant to startup businesses: "*manufacturing goods or services that do not meet customer demand or*

specifications" (Womack and Jones 1996). It is this waste that startups must be most careful of to avoid creating the wrong product.

2.1.2 Value

Value encompasses the elements of any business, product or process that provide measurable benefit to the customer. The first steps in applying Lean Thinking (or "Lean techniques") are to identify what the customer wants from the outcome, and then assess which processes are required to create this value, and which ones only create waste (Liker, 2004, pp.27-29). Giving priority to value-creating activities and valuable product features ensures that a business is making the most of its resources in pursuit of a successful outcome.

In startup businesses, value must be identified as early as possible in the development process to prevent limited resources being used up on features that are unnecessary and products that customers do not want (Blank, 2007 and Ries, 2011).

2.1.3 Flow

Flow (or "continuous flow") refers to smooth physical progress of parts, procedures and people in order to avoid delays and bottlenecks, and the pursuit of sequences and processes that avoid waste (Liker, 2004, pp.87-90). This can include factors such as strategic planning of factory layouts to ensure that components move from one machine directly to the next, coordination of personnel to prevent unnecessary downtime, and use of a "pull" system to ensure that parts are manufactured "just in time" and do not need to be stored (Womack and Jones, 1996).

For a startup (or pre-startup) business, these manufacturing examples are not yet necessarily applicable: however, in considering flow from the earliest possible stage, businesses can plan to make the most of what few resources they have available.

While continuous flow as sought after in manufacturing does not directly apply to businesses that are still searching for a product or business model, more relevant is Mihaly Csikszentmihalyi's definition of flow: "*The state in which people are so involved in an activity that nothing else seems to matter*" (Csikszentmihalyi, 1990, p.4)

The Lean definition of flow in manufacturing, when coupled with the psychological definition, suggests the importance of teams working smoothly to achieve a common goal. The challenge of the MATE programme is to achieve this flow in a fundamentally artificial situation, whereby the team members have been brought together not by their particular interest in the subject or belief in the proposed outcome, but by an academic goal.

Entrepreneur and writer Ash Maurya (2012, p.177) outlines several requirements for activities to flow:

- Clear objectives
- The team's full concentration
- Lack of interruptions and distractions
- Immediate feedback on progress towards objective
- A sense of challenge.

On the basis of experience documented in Chapters 3-5 the author suggests one additional requirement:

- Belief in the project.

2.2 The Lean Startup

Due to the influential work of Womack, Jones and Roos, Lean Thinking has grown beyond manufacturing to be used in many other industries, and has experienced a recent resurgence of interest in part due to Eric Ries' 2011 book *The Lean Startup.* The approach advocated in that book applies the fundamental functions of Lean Thinking to startup businesses, with particular focus on the software industry, where rapid customer validation and product iteration has dramatic benefits in an industry where speed to market is critical.

Lean startup is closely related to the customer development model developed by Steve Blank (2007) which encourages continually improved understanding of the end user in parallel with product development.

2.2.1 The Minimum Viable Product

The minimum viable product (MVP) is an early version of a product which includes only the features most critical to its success (Ries, 2011). By creating and selling this early version, startup teams can gather valuable information about customers and prove the viability of a product without wasting time on less important elements.

The MVP strategy is crucial for startups that are simultaneously trying to build products and a customer base, before running out of resources. Strongly linked to both value and waste, one of the main goals of the MVP is to determine which of the proposed features create the most value for the customer, allowing for those features to be developed first (Nobel, 2011).

By following the MVP model a startup business can quickly determine whether it is on the right track and prevent expensive detours caused by assumption and lack of understanding of customers' needs, thus preventing the creation of a product that nobody will buy. An MVP strategy will usually involve exposing customers to a version of the product that the creators themselves do not consider completely *finished*, but the feedback gathered from these initial customers will be invaluable in refining subsequent iterations of the product. Reid Hoffman, founder of LinkedIn and a Lean Startup practitioner summed up this predicament: *"If you're not embarrassed by the first version of your product, you've launched too late"* – the point being that founders must put learning ahead of egotistical self-preservation.

Applying this method repeatedly, with constant customer interaction, forms the basis of the "Build, Measure, Learn" feedback loop (Ries, 2011), also referred to as iterative product development.

2.3 Design Thinking

Design Thinking is the application of a designer's sensibility and methods to complex problems that are not necessarily design-based (Brown, 2008). It is a user-centred (also called human-centred) approach to problem solving: meaning that the solution is directly defined and refined through observation and communication with the end user.

Design thinking provides for a holistic view of product development that includes not only the product itself but empathy with the user and how he or she will interact with it. By considering users and including them (as well as engineers and specialists from other disciplines) in product development from a very early stage, businesses can ensure that the product will truly satisfy the users' requirements. While aesthetics are still an important component of product development, design thinking places considerable weight on the user, functionality, manufacture and communication in order to create innovative products that satisfy both needs and desires (Brown, 2008, p.86).

2.3.1   Inspiration

Inspiration is the point at which a problem becomes an opportunity with a direction. In a design firm this begins with a client's brief, while in a startup setting it is often based in the experience or research of the founder. Regardless of where it originates, inspiration often revolves around the need for a solution to a "wicked" problem.

"Wicked" problems

A basic definition of a wicked problem is that it is implicit, recursive, and has no simple answer. Horst Rittel proposed ten properties of wicked problems:

1. Wicked problems have no definitive characteristics

2. There are no criteria to determine whether a wicked problem has been "solved"

3. Solutions to wicked problems are not true or false; they can only be good or bad

4. There is no complete list of applicable "moves" to find the solution to a wicked problem

5. There is always more than one explanation for a wicked problem, depending greatly on the individual perspective of the designer

6. Every wicked problem is a symptom of another problem

7. No solution to a wicked problem has a definitive, scientific test

8. Solving a wicked problem is often a "one shot" effort, as the solution alters the situation, preventing scope for trial and error

9. Every wicked problem is unique

10. Anyone attempting to solve a wicked problem must be fully responsible for their actions.

(Rittel, 1972, as cited in Buchanan, 1992)

While these situations are often encountered within the domain of traditional product design, wicked problems can be found in any discipline or situation where no solution exists. Buchanan (1992) proposes that design problems are wicked because the scope of design spans all areas of human experience, rather than a particular subject. Accordingly, the broad spectrum of problem solving techniques encapsulated in Design Thinking makes this a useful tool in searching for solutions to wicked problems in many domains.

Observation

Due to its user-centred focus, inspiration in Design Thinking comes as the result of immersion in the user's environment and empathy for their situation. While traditional market research and communication are key elements, observation is even more a fundamental in providing the Design Thinker understanding not only of what is lacking from the current situation, but also the potential of what *could* be. Prior to the development of either Lean or Design Thinking, Henry Ford acknowledged that the customer can not necessarily comprehend a new idea until it has been created, "*If I had asked people what they wanted, they would have said faster horses*" (Ford, n.d, as cited in Brown, 2009). Design Thinking encourages close observation of the users to identify solutions they don't realize are possible, rather than incrementally improving on what they currently understand.

Constraints

Design Thinking encourages the recognition and understanding of the constraints of any situation in order to provide a suitable framework for the process. These constraints can be in the form of customer requirements, timeframes, regulation or any number of external influences.

2.3.2   Ideation

Ideation is where research, observation and background information are compiled and inform development of potential solutions to the wicked problem in question.

Conceptualization and Iterative Prototyping

Fundamental to this stage is speed; teams concoct scenarios based on their understanding of the market and rapidly generate multiple solutions to the problem. Prototyping occurs immediately, with the goal of generating useful user feedback without spending any more time, effort or investment than is absolutely necessary. This feedback informs the next generation of prototypes and the process repeats until the solution is perfected. This iterative process has much in common with the "Build, Measure, Learn" and Minimum Viable Product methods found in Lean Thinking.

Communication

Internal communication is vital within interdisciplinary Design Thinking teams to ensure that members with particular specialties report developments and work collaboratively. Externally, the team should be in regular communication with users, ensuring that the team vision stays in line with the users' requirements.

2.3.3   Implementation

Desirability, Feasibility, Viability

Design Thinkers strive for three essential elements considered necessary for a concept to be successful. Products must not only be *desirable* to the customer, (an attribute traditionally focused on by product designers), but must also be capable of being manufactured in a manner that is technologically *feasible*. Achieving both of these factors greatly increases the chances of achieving a *viable* business (IDEO, 2014).

Products or solutions that achieve only one or two of these criteria will find it difficult to succeed: for example a consumer product that is desirable but technically complicated is likely to be expensive to manufacture and therefore will not necessarily lead to a successful business model despite customer demand. The challenge for a startup business is to determine whether all three elements are achievable prior to investment in a solution.

Interdisciplinary teams

As a strategy for projects within the MATE course, Design Thinking is well suited as it uses multi-disciplinary teams to address problems that do not have one single point of origin. Commercialisation of science requires mastery of relevant technology and also an understanding of the market, users and competition. Through Design Thinking, teams can approach business problems in the same way that designers approach design problems: starting with an understanding of the customer.

2.4 Comparison of Lean and Design Thinking

A comparison of Lean Startup and Design Thinking (Mueller and Thoring, 2012) highlights the similarities and differences between the two theories.

Key Differences: (not all of Mueller and Thoring's identified differences)

What	Design Thinking	Lean Startup
Goal	Innovations	Innovations
Scope, Focus	General innovations	High-tech innovations for startups
Approach	User-centred	Customer-oriented
Uncertainty	Solve "wicked" problems	Unclear customer problem
Testing	Fail early to succeed sooner	Pivoting: prove or disprove a hypothesis, then update and retest it
Iteration	Yes (iteration of designs)	Yes (pivoting)
Ideation	Yes: solutions are generated as part of the process	No: product vision is initially provided by the founders
Qualitative Methods	Strong focus: extensive market research and observation of users	Not a focus
Quantitative Methods	Not a focus	Strong focus: metric-based analysis, testing
Business Model	No	Yes

TABLE 1: COMPARISON OF IMPORTANT ASPECTS OF DESIGN THINKING AND LEAN STARTUP

These two methods share a common focus on realizing innovation through close communication with the proposed user, with rapid iterative development based on prototypes.

Design Thinking's observational research bears some comparison to the Toyota Production System method of "going to Gemba": the process of going to the place where value is created (Liker, 2004). This allows management to interact with staff directly and observe production processes first-hand. This has been incorporated into the Lean Startup methodology using the original Japanese term *genchi gembatsu,* loosely translated as "go and see for yourself", and is closely linked to Steve Blank's directive to "get out of the building" (Ries, 2011 and Blank, 2007). The common thread is the importance of early direct observation in order to prevent over-commitment to an unsuccessful or unproven strategy.

Where the Lean Startup and Design Thinking philosophies differ greatly is in the initiation of the projects. Lean Startups begin with a business concept as proposed by the founder, the validity of which is then tested and the solution developed in response to user feedback. The goal of Design Thinking on the other hand, is to solve "wicked problems", whose solutions will be revealed by the process itself. This difference in the genesis of projects relates to the notions of "technology push and market pull". A technology push situation is one in which a product is developed in order to utilize a particular technology, while market pull is product development in response to an identified opportunity.

The Lean Startup advocates early use of the Business Model Canvas (Osterwalder and Pigneur, 2010) to develop the business model in parallel with the product. While Design Thinking does not include a particular business strategy, through close interdisciplinary cooperation it encourages a cohesive vision for projects, including necessary business elements. This may reflect the origins of Design Thinking in professional design practice, where involvement in projects is at the expense of clients, rather than self directed.

Roger Martin, Dean of the Rotman School of Management at the University of Toronto, has explored the application of design thinking to management. In *Design*

Thinking and How It Will Change Management Education: An Interview and Discussion
(Dunne & Martin, 2006) he considers a design thinking approach to projects in
comparison to the approaches taught in traditional MBA courses. Through observation
of the design process (itself the first step of design thinking) he has identified parallels
in the processes of top designers and top managers. Both designers and business
leaders must approach situations where there is no obvious solution, address the
constraints and work out solutions by thinking differently from everybody else.

Martin points out that while traditional, established businesses generally view
activities as ongoing, design businesses work on projects that have defined terms and
constraints. For managers, the ability to consider work as a series of projects and to
embrace constraints as stimuli to finding innovative solutions is posited as a valuable
skill. Applying a holistic approach combining intuition, reason and imagination,
managers and entrepreneurs can seek creative solutions that may not fit any existing
model. Similarly, exploring multiple paths suggests solutions that may not be reached
via a single method. The uncertain conditions of startup businesses and the
requirement of entrepreneurs to assume multiple roles in the initial stages is well
served by the adoption of these broad spectrum problem solving approaches and by
the application of Design Thinking to management. When applied to startup
businesses, this has the potential to solve problems and encourage innovation while
maintaining control with comprehensive overview of the project (Martin, 2006. Zilner,
2010. Boland & Collopy, 2010).

2.5 Summary

Over the course of the 2013 MATE programme, elements of both Lean and Design
Thinking were used. Due to the experiential process of the programme, these
methods were not used for the purposes comparison and analysis; rather, elements of
the two were adopted as pragmatic responses to the projects.

The selection of the Lean Startup recognised the goal of MATE to commercialise
research using a startup business format. While the Lean Startup's focus is software
development, elements of its validation process were considered appropriate for
ongoing research projects. Further, the preconceived directions of the proposed MATE

projects bore many similarities to a founder's vision that must be tested before a startup succeeds. The Lean Startup offers neither direction for genesis of new ideas nor strategy for pivoting beyond the abilities of the founding team. While commercial enterprises can adapt to this through appropriate team structure, this poses a challenge for the format of the MATE course.

As the year progressed and the team invalidated elements of the preconceived commercialisation paths, Design Thinking became suitable as a tool to identify alternative strategies. Its interdisciplinary approach is well-matched to the format of the MATE programme, as is its focus on identifying and solving undeterminable problems. Since the ideal application of Design Thinking is from the absolute beginning of a project, it is difficult to implement fully in the pursuit of commercialisation of ongoing research.

The inherent similarities of elements of Lean and Design Thinking allowed their concurrent use as the team's focus narrowed to user-centred product development.

The following chapters summarise the 2013 MATE team's application of Lean Thinking, the Lean Startup and Design Thinking to the given projects and address the implications of these methods for academic commercialisation projects.

Chapter 3 Project Conception: NacreTech and Sound Concepts

The 2013 MATE participants began the course with disparate training, experience and goals. The Lean Startup provided a common base from which to begin the transition of academic research into a viable business.

3.1 NacreTech

Professor Kate McGrath's nacre research was selected by Harker, Jimale, Walsh, First and Townend, under the moniker "NacreTech". After thorough evaluation and validation, the decision was made to cease work on the NacreTech project, due to the dramatically different speed and directions of the project's research and commercialisation aspects. While market response to the potential of the material was overwhelmingly positive (albeit with a slight shift away from dentistry) there was little the commercialisation team could do to influence or contribute to the physical material development required. In order to best use the team's skills and time, it was decided to report on the findings and return the project to the champion for further development. For more information on the results of NacreTech see Appendix 1 (MATE group report).

The proposed use of Nacre in veterinary dentistry was a practical application of Lean Startup MVP theory. An injectable gel that could fill voids following tooth extraction in animals would be comparatively simple to create and test, quickly establishing a presence for the material in the wider bone augmentation industry. The team found that while the core theory of this proposed plan was sound, there was no market demand. Veterinary tooth extractions are relatively uncommon and when they do occur, natural healing of the site is usually satisfactory.

Through the process of invalidating the proposed plan, the team identified options for nacre in orthopaedic practice. However this pivot highlighted the fact that without domain knowledge in chemistry or composite materials and only a crash course on the

research, the team was unsuited to developing a nacre-based business. As a link between the research team (with the technical knowledge) and the market (with the understanding of the problem) the MATE team was useful, but the attempt to build a business from scratch under these conditions resulted in a severe lack of flow as it became apparent how little the team was able to contribute to the project.

The primary learning outcome of this experience was the importance of appropriate team structure and domain knowledge. While the team was able to research and gain a basic understanding of both the technical background and market our lack of knowledge precluded spontaneous, disruptive innovation. We were heavily reliant on the expertise of the project champion and research team, whose objectives were not solely commercial.

The team was committed to the academic programme with its time and personnel constraints – the only variable was the project. At this point one member left the MATE programme.

3.2 Sound Concepts

The team (now Harker, Jimale, Walsh and Townend) shifted its focus to Sound Concepts. This had originally been discounted as it did not have a sufficiently "advanced technology" component to achieve the goals of the course. However since the initial pitch, the Sound Concepts project had developed to include elements of advanced acoustic theory and parametric modelling and was deemed to have scope for MATE development.

As with the work on NacreTech, Lean Startup methodology was adopted as a way of testing assumptions about the existing prototypes, to determine the viability of Sound Concepts as a business. Using the Business Model Canvas, the team proposed hypotheses around customer identity, deliverable value and how this could be created.

The team undertook market validation, focusing initially on primary schools as suggested by the existing research. While schools recognised interior acoustics as an important issue and were interested in the concepts, the acoustic performance was

not high enough to warrant significant expenditure. This conclusion was reached through a series of interviews over a two week period. This demonstrates how a quickly an impartial, commercially focused team can validate a concept, as opposed to an academic team whose objectives do not solely concern business viability.

Another factor to explore was the manufacturing process of the prototypes (TriForm and Pod) to determine the scope for improvement. The supply chain relied heavily on the source of the raw material, Autex Industries, who the MATE team was instructed not to contact directly. It became apparent that the relationship between the project champion and Autex had been complicated by prior events. As the only New Zealand manufacturer of polyester non-woven fabric, Autex has no local competition. Additionally, Autex already sell three-dimensional wall tiles that are produced by the same manufacturer as the Sound Concepts prototypes, Calvert Plastics Ltd. It became apparent that should Autex begin producing self supporting polyester structures, they had the capacity to do so.

These issues also showed that when considered as pre-production prototypes, the Pod and TriForm concepts were overly developed. Tim Brown (2008) states that *"Prototypes should command only as much time, effort and investment as are needed to generate useful feedback and evolve an idea. The more finished a prototype seems, the less likely its creators will be to pay attention to and profit from feedback".* While the prototypes allowed for testing of the structures' performance, it was potentially premature. Based on the findings of the MATE team, had thorough validation of the primary school market been undertaken earlier, with the express goal of determining the market need for these products, these prototypes may not have been deemed appropriate.

As the MATE team had neither been involved in the early stages of development, nor privy to early experimentation and interaction with customers, it was difficult to defend the existing prototypes when faced with negative information about their suitability for the intended market. The MATE team had no reason to continue with any particular strategy and inevitably looked for alternative applications. What was required was a market that demonstrated desire for a product that could be

manufactured and sold at an appropriate price point. This desired situation is referred to as a "product-market fit".

The team initially understood that we were joining Sound Concepts under the leadership of the project champion in order to further commercial elements of the research, helping to establish a viable commercial entity in which we would have a stake. This position was based on our understanding of the MATE course. In the process of investigating the commercial objectives it became clear that this position did not match that of the project champion, whose understanding of the MATE team's role was more like that of a consulting arrangement, whereby the team would explore commercial opportunity *for* Sound Concepts, rather than as *part of* Sound Concepts. While useful as further experience of market validation, Sound Concepts did not provide scope for pivoting or further development based on the results of the investigation. This disconnect was illustrated by outcomes of objectives set for the MATE team.

Objective	Outcome
A community hall pilot installation	After the initial pitch, the team received no further direction from the project champion regarding this installation, focus having transferred onto new Sound Concepts prototypes. Following investigation of the primary school market for these concepts the pilot installation was not a considered a priority.
Continued collaboration with consultants to determine the optimum configuration for primary school classrooms	Determining the optimum configuration for primary school installation proved to be premature as validation did not prove schools to be a viable market entry point.
Investigation of the TriForm design for use as a breakout space in classrooms and offices	Investigation focus shifted to office space, though not particularly the TriForm concept, which proved to be cost prohibitive due to the size and labour intensity of the individual pieces.

Objective	Outcome
Application for funding to present in Tokyo and/or New York	The MATE team had no interaction with, or involvement in this process as it applied to new concepts rather than the existing prototypes.
Investigate production capacity and delivery methods to supply market	This investigation was done, though some constraints were placed on exploration of alternative supply chain options by Natasha Perkins, due to existing relationships with material suppliers and manufacturers. TriForm was found to be prohibitively expensive due to the labour intensive production process of its multiple small components.
Formalisation of intellectual property registration for TriForm and POD designs.	Both the Pod and TriForm designs had been displayed in the public domain prior to MATE involvement, creating issues for IP protection. As the focus of both the MATE and Sound Concepts research teams moved on to other prototypes, this became less relevant.

TABLE 2: OBJECTIVES OF THE MATE SOUND CONCEPTS PROJECT

In hindsight, these objectives highlight that the TriForm and Pod products were considered "finished"; there was no mention of continued market validation or product development. The MATE team began the project on the understanding that the process of forming flat acoustic sheet into 3D shapes improved its acoustic performance, thereby providing the basis of a viable business. While this theory is correct, its application to acoustic panelling is neither exclusive to Victoria University nor Sound Concepts. Additionally, this technique did not translate into quantifiable value for the end user, making it difficult to achieve scale and justify costs.

Having followed the project champion's commercialisation strategy for the prototype's use in primary schools, the team identified a more promising market entry point – in commercial office spaces. The current trend in offices is for open plan workspaces, which while efficient and cost effective, do offer challenges to both workers and office managers who seek privacy and productive workspaces. It became

clear that we had identified a significant issue: the need for private spaces within a public (open plan) environment.

This pivot highlighted a key difference in the MATE team and the project champion's positions. From the MATE team's perspective the Sound Concepts commercialisation strategy presented a "technology push" situation – being finished products needing a validated market. What was really required was "market pull". The team now stopped concentrating on the strategy that had been proposed for us and began to make use of those we were identifying ourselves. This realisation of new opportunities marked a significant change: it was the beginning of the team's "design thinking" phase.

For more information on the results of Sound Concepts see Appendix 1 (MATE group report).

3.3 Analysis

Both NacreTech and Sound Concepts were pitched to the MATE students as developed prototypes with clearly defined proposals for commercialisation. While the team had scope to explore alternative applications for the research, it was difficult to achieve these without domain knowledge or understanding of the development paths to date.

Predominantly using Lean Startup methodology – which was appropriate given the preconceived vision of the champions – the team considered both cases to determine the proposed strategies' viability.

3.3.1   Waste and value

The Lean Startup is well suited to "technology push" situations as it provides a structure to test hypotheses and identify a suitable market. Its challenge is to quantify market need and apply technology as a product that meets customers' demands and specifications, rather than creating Womack's eighth form of waste by developing a product that does not. Customers do not necessarily recognize value created by unique manufacturing processes, but rather by the product's performance and cost.

NacreTech is a classic example of tech push. The material was developed via an academic research process without commercial focus. Market validation undertaken

by the MATE team determined that the original value hypothesis – synthetic nacre as a filler material in veterinary dentistry – was not viable but that the technology was of interest to veterinary orthopaedic surgeons. By identifying this crucial distinction early, the team prevented unnecessary product development (waste) and were able to suggest focus for ongoing research. To achieve these revised goals, further material research and testing was required. This created an impossible time constraint for the MATE team who ceased full time focus on NacreTech to prevent wasted resources. Noting that the team were attempting a startup format, this "all in or all out" decision was sensible for both the NacreTech project and the MATE programme as a whole.

Sound Concepts is closer to a "market pull" situation, based on a need identified by the research team for control of acoustic reverberation in interior spaces. However, as a solution had already been developed prior to MATE involvement, Lean Startup was again suitable to test the solution's viability. The team's validation of this proposal was again crucial to determining whether the TriForm and Pod prototypes met the end users' requirements. To borrow from Design Thinking terminology, while customers who were shown the Sound Concepts prototypes recognised the "cool" factor of the products (desirability), and it is technically possible for them to be manufactured (feasibility), the team concluded that the finished products' cost and the constrained supply chain rendered the business plan untenable (viability).

3.3.2   Flow

Without the investment of time or money, and without belief or vested interest in the concepts, the team struggled to gain traction on either NacreTech or Sound Concepts. Lacking any ability to influence the direction of the research projects (and subsequent product development) the team members were left to take up diminishing aspects of commercialisation.

The lack of energy, lack of role diversity and lack of real understanding or inspiration left the team feeling distinctly un-entrepreneurial, while the predetermined direction generated a feeling that it was not our innovation – we were merely parts of a larger process that we did not fully understand.

Considering Maurya's requirements for flow with regard to the two MATE projects highlights the problems.

Requirements for Flow	NacreTech	Sound Concepts
Clear objectives	Initially yes, but not once that had been addressed	Yes, but once proven unsuitable, no further direction
The team's full concentration	No	No
Lack of interruptions and distractions	No	No
immediate feedback on progress towards objective	Self-directed	No
A sense of challenge	Yes	No
Belief in the project	Yes, but not in teams' ability to realize it	Limited

TABLE 3: FLOW IN NACRETECH AND SOUND CONCEPTS

3.3.3 Minimum Viable Product

The NacreTech MVP was a valid proposition that, if successful, would have provided valuable information and early revenue, informing development of subsequent NacreTech products. However, as shown by the team's validation, while this product would theoretically work as predicted, it did not address a significant problem facing veterinarians and so did not constitute a *viable* market entry point. While an established business could absorb losses incurred by such a product, it would rely on potential for substantial future earnings, a potential not yet established by NacreTech.

For Sound Concepts, invalidation of the primary school market showed that the prototypes had been developed beyond the point where user feedback could inform their refinement. This situation could be considered as an example of a Lean Startup: the founder's vision has been tested and found to not adequately address the user's need. Further, the prototype was over developed and had absorbed more time and energy than was required to determine its value.

3.3.4   **Team**

The MATE team members found it difficult to identify roles while all engaging in market research and validation.

The author, as the sole member of the team with experience in design and manufacture, assumed some responsibility for elements of the projects relating to the physical products. In NacreTech this involved consideration of methods of application for nacre in veterinary dentistry and would likely have progressed into product development had the proposed product proven viable. Sound Concepts initially suggested a good fit considering its foundation in design; however it became clear that the project champion did not require any design input from the MATE team. The author's focus adjusted to the production process and supply chain, however this was fundamentally a subset of the team's overall validation process.

While the team was technically interdisciplinary, the small intake in this inaugural 2013 course meant that there were limited skills available. Instead of selecting skills and personnel – which would be the case in a commercial entity – we had to compromise, making the best of what we had. While market validation is acknowledged by the team as vital to the success of any business, this role uniformity did not match the team's expectations of the course.

By handing over select elements of the projects (nacre as an injectable gel, Pod and TriForm) the product development and commercialisation elements became separated and one was unable to inform or influence the other. Members of the team felt like "consultants", contracted to validate a concept but with no control of its outcomes.

On both projects the team lacked productive working relationships with the project champions, leading to a lack of flow, enthusiasm and clarity. Much is written about the importance of suitable structure and good communication in founding teams (Italie, 1999., Blank, 2013., Kim & Aldrich, 2004), the common theme being cohesion, whereas both the NacreTech and Sound Concepts projects resulted in "us and them" situations.

Critically, while the research elements of the projects were ongoing, the project champions made no commitment to a common effort. In a commercial setting this situation would be untenable. While the precedent for the licensing of technology to third parties is well established, this usually requires the third party to have some expertise in the field. If a business team were to license a piece of intellectual property (with no ongoing involvement with its creator) then the team would require an understanding of the technology on a par with the creator, and a vested interest in its use. Without those elements the team would struggle to secure investment or the license to begin with.

Having attempted to follow the project champions' preconceived paths, the team determined alternative strategies were required. In the case of NacreTech, this pivot point left the team well out of their depth technically and with no alternative market identified. In the case of Sound Concepts however, when the original strategy was ruled unviable, the market knowledge and understanding gained through the research suggested a promising alternative.

Upon presentation of its course work in December 2013, the team was asked about the decision to cease work on NacreTech, as the technology had shown significant promise. The poser of the question, Phil McCaw from venture capital firm Movac, also discussed the importance of team composition in startups. The answer to McCaw's question lies in his point on teams: our team, with no domain knowledge of composite materials or veterinary health, felt unable to add any value to the technology of the project.

3.4 Summary

The Lean Startup has proven a useful tool for testing and validating the commercial prospects of NacreTech and Sound Concepts. Starting with existing research and validating a predetermined course of action has resulted in changes in strategy and highlighted significant issues concerning the team structure for the proposed commercialisation.

While the Lean Startup is well suited to the testing of hypotheses, it does not provide direction for identifying of alternatives once the initial plan has been invalidated. This reflects a key assumption of the Lean Startup, that the founding team includes appropriate technical capabilities to pivot in response to market requirements.

Chapter 4 Project Realignment: Hyv

The team now understood a market - open plan offices - experiencing a significant problem - distraction due to noise and a lack of privacy. To differentiate this new phase from the Sound Concepts project, the team established the team name Hyv, pronounced "hive".

4.1 Position following Sound Concepts

Through investigation of open plan offices as a market for Sound Concepts products, the team had developed a thorough understanding of a familiar niche. In contrast to NacreTech, as Hyv the team was able to utilize prior experience (of working in open plan situations) and leverage existing contacts (workmates, architects, designers and builders) to explore a "wicked" problem in commercial offices: the effect of open plan layouts on productivity, privacy and comfort.

4.2 HyvSC

Initial investigation of open plan offices had shown awareness of the importance of acoustics and privacy, and acknowledgement of the value of "breakout spaces" as a means to address these. Office fit outs can be expensive and the team proposed a modified Sound Concept system (HyvSC) to provide acoustic benefit and layout versatility while remaining cost effective in comparison to custom made breakout spaces.
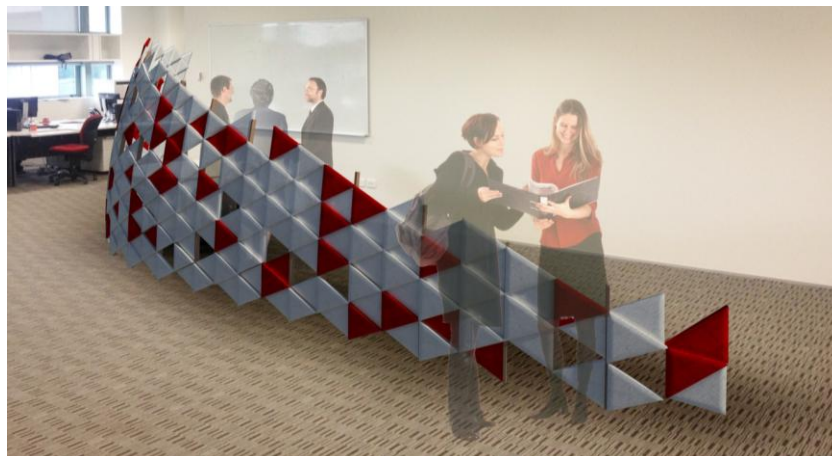

FIGURE 3: HYVSC OFFICE PARTITION SYSTEM

Customer reaction to this concept was positive; however feedback suggested that the bold aesthetics of the system could be polarising. The proposed system was considered excessively sculptural for use as a divider in general office space, while businesses looking for "statement" pieces with a high design aesthetic wanted unique custom installations that would set their office apart. The team met with local company Anderson Design Ltd who confirmed industry recognition of the need for office breakout spaces but expressed scepticism over a "one size fits all" system. If necessary, these Sound Concepts based fit outs could be produced as custom installations, rather than standardized products.

The HyvSC proposal, while user-centred and developed in response to market demand (therefore closer to Design Thinking), was constrained as a variation of an existing idea. It was neither "technology push" nor "market pull", as elements of both were present. While the application of an existing technology to a new (or newly identified) problem appeared to have some potential, HyvSC bore more in common with a niche service provider, rather than a scalable enterprise. Once again, the team felt the concept did not provide enough value to warrant continued development.

4.3 A Clean Slate

By setting aside existing concepts and adopting a purely user-centred approach, the team was able to assess problems in open plan offices without preconceived notions of how to solve them. An understanding of the market from the perspective of the end user (who would benefit from the resulting product) as well as an understanding of the decision making process in office fit outs, allowed the team to consider how best to address the situation and develop a set of criteria that would inform subsequent product development. Tim Brown (2009) states that "*Design Thinking starts with divergence, the deliberate attempt to expand the range of options rather than narrow them*".

4.4 Analysis

Hyv was an attempt by the team to use user-centred methods to develop a solution to an identified problem faced by a particular market. Design Thinking was one of several

contributing theories used at this stage, the common theme being strong emphasis on user interaction that would inform product development (Brown, 2010), ensuring the creation of value that would benefit the end users (Cai & Freiheit, 2011).

4.4.1   Inspiration

While three of the four Hyv team members had direct experience of working in open plan offices, it was the work of Natasha Perkins and the exploration of alternative commercialisation paths for Sound Concepts that provided cause for the research and understanding that became Hyv.

In the process of validating Sound Concepts, the team spoke to over one hundred people including architects, designers, school staff, office managers and office workers. Fully focused on commercial offices, the Hyv team now attempted to determine the biggest "pain" experienced by workers. This research loosely resembled Design Thinking techniques, but not intentionally. The process was in fact an amalgamation of theories based on the work of Brown (2009), Blank (2007), Ries (2011), Adams (2010) and others. This reflects a significant element of the MATE course: learning by doing, rather than researching *then* doing. Diverse literature, as well as mentors and internal discussion, was influencing the individual team members, who by this stage were better able to differentiate between roles. Through interviews, cold calling and surveys the team gathered information regarding the wicked problem that some office workers experience.

This is the problem determined by Hyv:

> Noise pollution and lack of private space in open plan offices causes worker distraction and reduces productivity.

This was expressed to varying degrees by office workers, managers and architects, and while not all respondents agreed on the severity of the issue, it largely conforms to Rittel's criteria for wicked problems.

The effect of this problem is difficult to quantify, particularly considering that one solution will affect multiple users who may not agree on the outcome. Workspace conditions are determined by multiple factors including acoustic, spatial and personal

considerations which affect users differently. As such, the solution will not be achieved by a set of standard steps, and is unlikely to achieve total success from the perspective of all users.

These are the requirements for a product-based solution to this problem:

- Reconfigurable
- Not fully enclosed
- Must work with existing services
- Max 180cm tall
- Free standing
- Simple to install (by the user)
- Optional accessories (whiteboards, pin boards etc)
- Aesthetically pleasing
- Cost effective
- Lightweight
- Simple connections

In considering these requirements the team had to allow for users' varying definitions, for example aesthetics. This list formed a starting point from which to *build, measure and learn*. Interestingly users were less concerned with acoustics and more with privacy and some office managers wanted a productive "buzz" rather than attempting to eradicate noise. More important was to provide staff with options for "spaces within space" so that potentially distraction causing activities could be moved away from the communal desks into semi-private meeting spaces.

As well as these functional requirements, the team also had to consider product constraints including:

- The users' budget
- Flammability
- Effect on existing building services

As well as team constraints:

- Prototyping budget

- Timeframe

- Team capabilities (see 4.4.4)

4.4.2 Ideation

Having defined the "must have" user requirements the team translated those into a product specification. The author, in a newly realized product developer role, considered how user requirements could be achieved from a production perspective (considering materials and processes). Meanwhile team member Liam Harker produced a computer rendering of a divider system that would address the key functional requirements. The fact that Harker (with no design training or experience) was able to design the first concept in response to user-requirements is testament to the benefit of a user-centred design process. The initial rendering, while rough, was enough to show users and gather feedback which informed subsequent iterations.
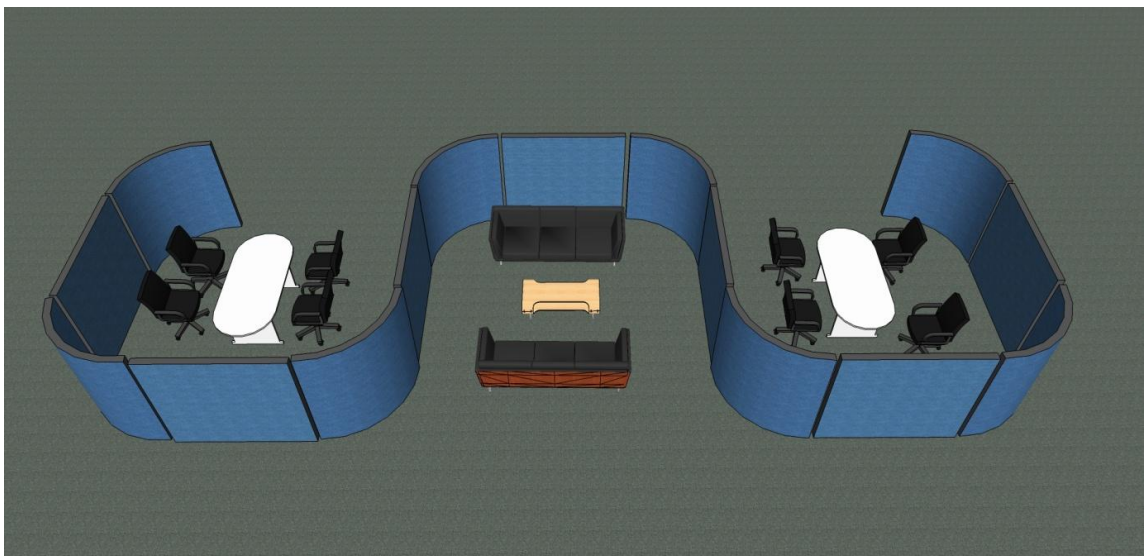

FIGURE 4: HYV PARTITION CONCEPT

A two dimensional rendering of a three dimensional product could only go so far towards determining how users would interact with the system. A prototype was constructed that would test functional elements of the system including the dimensions, weight, configurations and overall "feel" of the spaces created. The goal of this prototype was not to solve or even address every element of the product, but to learn about its strengths and weaknesses.

Heavy duty corrugated cardboard was used to construct the first prototypes and proposed for use as a Minimum Viable Product. This had significant implications as it exposed a difference of opinion concerning the appropriateness of showing a rough prototype to potential customers. The author considered it necessary to involve customers immediately in order to prevent the refinement of unnecessary features. Other team members were concerned that by revealing the "cheap" structure, the perceived value (and therefore potential sale price) of the resultant product could be negatively impacted. This highlighted the marketing and sales focus of some team members, as well as the fact that Design Thinking had not been comprehensively adopted as a strategy. A compromise was reached via a somewhat refined prototype which was used in a series of customer interaction sessions.

Considered retrospectively, this ideation effort was not broad enough to constitute true Design Thinking conceptualization. Rather than generating multiple solutions and allowing user input to develop them, the team quickly focused on the one idea that seemed to address the problem best and then sought to refine it.

FIGURE 5: HYV1.0 PROTOTYPE

4.4.3   Implementation

At the time of writing the current prototype (Hyv1.0) has not been developed further due to team focus on completion of MATE academic requirements. The requirements for further development and ultimate viability of the Hyv project will be discussed in chapter 5.

4.4.4   Team

The transition from technology push to market pull allowed the Hyv team to establish distinct roles, making use of individual skills and experience.

- Liam Harker: Operations and business strategy including business model and exit strategies identification.
- Ish Jimale: Market research into office space niches and definition of product specification.
- Ian Walsh: Marketing, sales, customer development and branding.
- Oliver Townend: Product development: Building on his training in industrial design, the author led product development including conceptualisation, prototyping and investigation of materials and processes from which to create the MVP, "Hyv1.0".

The team had defined roles, but the structure was non-hierarchical, meaning that all decisions were reliant on general consensus. This reflected the way the team was originally assembled, with no management structure other than academic supervision and external mentors. Rather than a team created specifically for a particular project (with inclusion based on individual experience, thereby creating structure based on specific roles), the team were attempting to conform our existing skill sets to roles required by the project. This is in contrast to similar university-run commercialisation and entrepreneurship courses (Baker, Mark, Leinonen, 2010. & Boni, Weingart, Evenson, 2009) which recruit relevant team members for specific projects.

With better role definition came better internal communication. Individuals assumed responsibility for contacts and conversations relevant to their focus, the information from which was then relayed to the rest of the team via regular meetings and the use of digital task tracking and networking systems such as Yammer (Yammer, 2013) and

Trello (Trello, 2013). The effectiveness and productivity of internal communication was also strengthened by the cessation of regular contact with the Sound Concepts research team. Without the imposed path and objectives of the original concept the team had freedom to brainstorm ideas and debate strategies in direct response to results of the market research and prototyping. While individuals did not always agree on what the next step should be, the team was at least in charge of its own direction.

The four team members had by this stage established the focus of their individual theses and begun research into literature and theory relevant to their discipline. The one theoretical model that all team members had in common was an understanding of the Lean Startup. While useful as a market validation tool, the Lean Startup was not established with physical product development as the focus. The broad range of market research, product development, strategic, sales and marketing concepts that the team members were using began to have a complicating effect. With no chief executive officer to have the ultimate say on strategy or process the project sometimes resembled a whirlpool of contradictory directions.

4.4.5 Flow

"Thus transformed, work becomes enjoyable, and as a result of a personal investment of psychic energy, it feels as if it were freely chosen, as well."
(Csikszentmihalyi, 1990, p.152)

Although flow and momentum were greatly improved in this self directed product development process, the team was still greatly affected by the academic requirements of the course. While we were acting as, and attempting to make decisions as a business, we were working within an academic timeframe and were therefore unable to cease operations in spite of a weak business model. This continued as a way of getting the most out of the learning situation. As Geoff Todd, managing director of VicLink, put it to the MATE students in January 2013 "*Don't be afraid to walk away*", yet we were unable to.

Again considering Maurya's requirements for flow there is a distinct improvement yet still problem areas, mostly stemming from the part-time nature of student work.

Requirements for Flow	Hyv
Clear objectives	Self-determined; much clearer objectives due to acceptance of project in order to achieve academic goals
The team's full concentration	No, but improved
Lack of interruptions and distractions	No
Immediate feedback on progress towards objective	Completely self-directed; difficult due to non-hierarchical team structure
A sense of challenge	Greatly improved
Belief in the project	Belief in the concept – debate over its viability as a business

TABLE 4: FLOW IN HYV

A common mantra in startup businesses – "you're either all in or all out" was relevant to the Hyv situation, yet difficult to live by, as we could neither commit fully (confident in the belief that our personal investment would ultimately be rewarded by the success of the business) nor quit the project entirely (and waste our investment in the MATE qualification).

4.5 Summary

As an exercise, Hyv allowed the team to work towards a result that would be unobtainable in the available timeframe had we repeatedly invalidated commercialisation projects. To that end a conscious decision was made to continue with Hyv in order to maximise our learning opportunities from the MATE course. Once this decision was made it became easier to build momentum and to achieve some semblance of flow.

By adopting a user-centred approach to a market pull situation, Hyv was able to explore and develop a solution to a wicked problem. At the time of writing, this process has not been completed; however progress to date has expanded access to users whose input (in combination with an understanding of Design Thinking) will provide a platform from which to continue product development.

Chapter 5 Project Refinement: Hyv2.0

This chapter addresses the future of the Hyv project and considers its viability as an ongoing enterprise.

At the present time the Hyv team is faced with several important considerations:

- Have we identified a clear business opportunity with growth potential?
- If so, how do we proceed?
- What form should our business entity take?
- Do we want to proceed at all, individually or as a team?

As product development lead the author faces a separate but related set of considerations:

- Have we created a solution to the identified problem?
- What work is required to develop this solution as a viable consumer product?
- What resources are required to achieve this?

Considered in isolation, the product development questions highlight the fact that Hyv is still a concept, which requires a comprehensive development effort. Whether this development is appropriate relies on positive responses to the overriding business issues.

5.1 Current position

The Hyv team has identified a wicked problem in commercial open plan offices. Office managers and workers have expressed a need for multi-purpose collaborative spaces that can be easily configured by the users, providing a sense of privacy, acoustic separation and a productive working environment.

Analysis of the competitive environment has shown that there are some products on the market that address this issue, but that users have limited awareness of these.

Further, user feedback has shown dissatisfaction with the expense of current products given their level of functionality.

Feedback from the target market on the concept of the Hyv1.0 prototype has been positive, while structural and aesthetic considerations are accepted as work in progress.

An expression of interest has been made regarding use of Hyv1.0 in its current cardboard form to fit out a temporary office. The three month lifecycle of the entity is ideally suited to Hyv1.0's low weight and low cost, and this installation would provide valuable feedback over a predetermined timeframe. The atypical nature of the office in question suggests that this is likely to be a one off occurrence, rather than a repeatable model. This is however a valid application of Minimum Viable Product theory, as the requirements of the customer are met by the current product, in spite of its unrefined form. In general, our market research has shown that businesses forced to make temporary arrangements (due to natural disasters, location changes etc), make do with whatever they can find, rent or buy rather than purchasing "throw away" furniture, which is seen as an unnecessary waste.

Another expression of interest has been made to trial Hyv1.0 in order to explore options for an upcoming office re-fit. The inquirer has been unsuccessful in finding an existing solution with the versatility of Hyv. The trial is scheduled for March 2014 and if successful could lead to the use of Hyv workspaces as part of the permanent fit out from 2015.

The positive reaction to the Hyv1.0 prototype indicates that potential customers see beyond the present under-developed aesthetics and materiality, while accepting the functional goals. However, meeting the requirements of a select group of users is just one part of creating a viable business. While Hyv have established the desirability of the concept, the feasibility of production will not be known until its form has been resolved. The ultimate viability of the business is not yet determinable but the level of customer demand is encouraging.

5.2 Necessary next steps

5.2.1　Product development

Hyv1.0 is currently little more than a test rig, requiring significant validation and development to achieve a "finished product". The further development requires significant research, design and engineering input. While the author has adopted the role of product development lead for the purposes of Hyv as a university project, this was a pragmatic decision for the purposes of the course. Continuing development would require a team that is concerned primarily with research and development of furniture-based office solutions and has a commitment to an ongoing design process. The creation of this ideal team as a startup business requires some indication that the proposed entity will ultimately be profitable. This fundamental element has not yet been sufficiently proven by the MATE Hyv project.

5.2.2　Customer development

In order to sustain a user-centred process, Hyv – as a business entity – needs to continue to develop a network of potential customers in order to gather feedback, refine the concept and generate sales.

5.2.3　Business development

In order for Hyv to be scalable and competitive as a producer of furniture-based office solutions, it would be necessary to develop multiple products and markets. This touches on a crucial next step for the team: determining the legal and organisational form which the continuing entity takes. Product manufacture in New Zealand is limited by our isolation from world markets. This is shown by successful local furniture company Formway's transition from manufacturer to design house. Unable to compete globally while manufacturing in New Zealand, Formway Design now license their intellectual property to international companies such as Knoll. As three quarters of the Hyv team have no background in design or manufacturing, outsourcing or licensing Hyv products would seem to be an appropriate business model. This would rely on the ability to protect the intellectual property of Hyv designs, probably through design registration. We accept that while this would provide *some* security, the concept of Hyv is not so novel that competitive businesses could not copy it.

5.3 Decision point

Crucially, the decision about continuing Hyv is entirely up to individual team members. Freed from the requirements of the academic course – to continue regardless of personal interest or misgivings – the team members can now assess their stake in the project and decide whether to continue with a purely commercial mindset.

Team dynamics are a recurring theme in entrepreneurship, lean and startup literature. Feedback from the judges of the MATE presentations included the importance of building teams with appropriate skills and experience, yet the Hyv team consisted of people available through the course, in a group initially formed to work on a completely different project (NacreTech).

5.4 Summary

At the time of writing, Hyv is a concept for reconfigurable panels usable in the creation of semi-private breakout spaces in open plan offices. This concept has been shown to have demand from office managers and workers and could provide an alternative to current costly fit-out systems.

Stating a firm position on the viability of Hyv is currently difficult as the concept requires significant further validation and development of the design. The current value of "Hyv" is in the team's understanding of the problems created by open plan offices, its network within that market, and its validated concept. Presently, this value is difficult to quantify.

Were we to reach a stage where a design had been finalized ready for production (with appropriate intellectual property protection) this Hyv design could potentially be licensed to a furniture manufacturer, either in New Zealand or offshore. It could be difficult to achieve a satisfactory licensing agreement if the Hyv business had only one product to offer. Additionally, even with design registration, should the versatile workspace concept prove successful, Hyv would face competition from similar products. As one product among a portfolio of related furniture systems, Hyv could achieve a lasting market presence, but in isolation the investment required to achieve production of a sole product is likely to be unjustifiable.

An alternative would be to develop Hyv as a service provider specializing in custom design work for office fit-outs. Building on the Hyv1.0 prototype, a system could be developed to construct breakout spaces as permanent fixtures. This might lack the finesse of a mass produced "product", having more in common with carpentry. This strategy, even more so than developing Hyv as a product, requires the ongoing involvement of a team. The author, in carpenter guise, could create and operate this business, satisfying the breakout space requirements of either of the current potential customers. Decisions on this involve consideration of personal goals and its potential for growth when compared to other business opportunities.

While elements of Design Thinking were utilized in the development of Hyv, its further development as a business would benefit from the comprehensive adoption of this strategy, in order to provide a benchmark process to work to. As the basic Hyv concept is further refined, Design Thinking grows closer to the Lean Startup, which through early consideration of business models, contributes to achieving product-market fit and business success. Regardless of whether Hyv products were manufactured in-house or licensed, the fundamentals of Lean manufacturing will become more relevant to the success of the ongoing operation, as the business proceeds from conceptualization to manufacture.

Chapter 6 Conclusions

This chapter reviews the implications of Lean and Design Thinking for management of academic commercialisation projects, with specific reference to the structure of the Masters of Advanced Technology Enterprise course.

Based on the author's experience as a team member on the Nacre, Sound Concepts and Hyv projects, the conclusions are intended to suggest how these theoretical models could be utilized in future offerings of the MATE programme.

6.1 Lean and the Lean Startup

While the core principles of manufacturing-derived Lean Thinking are relevant to any business, the Lean Startup – with its focus on early stage businesses – is more immediately useful to academic-based commercialisation ventures. Once the project is well established, the Lean techniques of identifying value, reducing waste and improving flow will come into their own.

Pure Lean Startup methodology is appropriate for tech push situations where a market must be identified to provide an application for an emerging technology. Projects that have origins in academic research are fundamentally "ongoing" and so have at least some proposed direction, making them more suitable for Lean Startup development. However, as university research is usually undertaken to achieve purely academic, rather than commercial objectives, it is reasonable to expect that while technologically viable, not all research will prove suitable for commercialisation.

To make best use of the Lean Startup technique, the project champion needs a regular and ongoing relationship with the commercialisation team. He or she should be a team member with the same objectives as the others, ensuring that the team has the ability to pivot and persevere with the project, even if the new direction differs from the alignment of the original research. As the instigator of the project, the champion's knowledge of the technology, belief in its value and commitment to its continuation is vital. When this is not possible (because of time constraints for academic staff, for instance), teams should be recruited with input from the project champion and should

include individuals whose skills are well matched to the project. This would ensure adequate internal domain knowledge for the project's durability through minor pivots. A lack of relevant expertise within the team may lead to its inability to progress past validation. Should a project pivot beyond the scope of the champion's expertise, a decision must be made as to whether to continue with the same team. Such a decision would occur in any commercial enterprise.

6.2 Design Thinking

As a product development tool, Design Thinking is ideally suited to the identification and exploration of complex problems and to the generation of product-based solutions. As a management tool, Design Thinking can be used to cohesively plan and structure projects involving multiple disciplines and requiring creative approaches.

As with Lean Startup, commercialisation teams using Design Thinking will benefit from close cooperation with the project champion. While tailoring teams to the proposed area of research is still ideal, the collaborative, interdisciplinary nature of Design Thinking makes it highly adaptable in constrained situations, such as those afforded by the MATE course. The ideation process of Design Thinking may not always be applicable to more complicated scientific projects: however, as demonstrated by the conceptualization stage of Hyv, when user feedback informs product development, it becomes easier for non-designers (and potentially non-scientists) to propose solutions to situations outside the scope of their experience.

In an academic setting, Design Thinking methodology may be applicable when the project champion has, either intentionally or accidentally, identified a complex problem to which no existing solution can be applied. In order to be effective in the creation of consumer products with significant market appeal, Design Thinking (or a similarly user-centred process) must be present in the research process from the outset. This early consideration will determine whether a proposed technology has potential for commercial application, in which case the research strategy should be tailored to that end. Similarly, identification and exploration of a user need prior to the involvement of a particular technology may provide scope for collaboration across academic disciplines.

6.3 Combining two methodologies

Regardless of whether a project arises from technology push, market pull or serendipitous inspiration, its potential for commercial success must be tested and proven to justify the ensuing significant investment of time, money or other resources. Interaction with the end user should begin as early as possible, with observation, qualitative interviews, quantitative research or whatever further technique is deemed appropriate. An understanding of the intended customers and their specific expectations or requirements will allow teams to focus attention on features that offer the most value and therefore create the best possible basis for a sustainable business strategy.

Critical to both Lean Startup and Design Thinking is agility and the ability to adjust quickly to in response to user-feedback. While these pivots are essential in establishing a product-market fit, the ability to shift the focus of the team relies on its flexibility and the commitment of team members. As shown by Hyv, even an inexperienced team can rapidly ascertain the commercial viability of a project, and while "failing fast" is an important element of Lean, Design Thinking and MATE, it does not necessarily allow for the constraints of time and of the academic course. Given that not all commercialisation projects will prove viable, and that all will experience significant strategic adjustments, MATE teams must accept the implications of these pivots. With prior consideration given to these possibilities, clear objectives and regular, scheduled updates, teams will mitigate the unforeseen risk of projects suddenly failing.

The use of a rapid iterative process – whether to validate hypotheses, brainstorm concepts or refine prototypes – ensures that teams explore multiple alternatives quickly. This is well suited to commercial interests. In an academic setting, particularly with regard to complex scientific projects, this rapid development may conflict with the timeframe of research goals.

MATE teams must identify and address the constraints of any project, which include team skills, academic commitments, the original research topic and research team. Other constraints will be more commercial and legal, likely pertaining to matters of

funding, intellectual property and regulation. While it may not be possible to address all of these factors within the scope and term of the MATE programme, the team can develop a project brief and a set of achievable objectives by acknowledging them early.

6.4 Flow

In order for MATE commercialisation teams to assume the role of startup founders and develop viable businesses based on academic research, conditions must exist that ensure the teams are supported and provided with a framework that allows for inevitable pivots over the course of the projects. While no team would pursue a business without potential for success, the MATE programme as currently delivered does encourage a degree of perseverance, even beyond the point where a commercial entity would deem the venture a failure and cease operations.

The most significant period of sustained flow achieved by the author's team occurred during the latter stages of the Hyv project described in Chapter 4. By this time the team had accepted that the project did not have potential for significant growth, despite providing sufficient experience of user-centred product development. This enabled definition of clear objectives for each team member, while the impending deadline of the academic programme provided an incentive for sustained concentration towards a final presentation.

Belief in a project's value is difficult to create from scratch in startup teams that have no domain knowledge of the background research or market need. Generating momentum and enthusiasm in a startup (that is unable to pay wages) requires the founding team to believe strongly enough in the ultimate goal that they will do whatever it takes to succeed. For an academic startup entity to assume commercialisation efforts of ongoing research, this belief has to be passed on from the project champion, whose understanding of the technology has sustained the project thus far.

6.5 A proposal for MATE V2.0

The following is a proposal for an inspiration process that uses Design Thinking to identify potential MATE projects from the spectrum of current research at Victoria University of Wellington.

Rather than accepting preconceived projects, problems or areas of research, the MATE programme may benefit and leverage its position as an innovative, interdisciplinary entity by requiring its participants from the outset to proactively explore and identify commercialisation projects from the full spectrum of research at the university.

In this context, the introductory segment (ATEN501) of the course would involve MATE participants meeting and interviewing researchers and senior faculty from all university departments, to obtain an understanding of current research projects and inhibiting issues. Students would report to each other and collate information on current research. Using a Design Thinking ideation process the students would then seek potential overlaps and complementary research which suggest collaborative projects. This could potentially connect branches of the university that currently have no obvious incentive for collaboration. Even if no suitable projects are identified initially, exposure to a wide a variety of topics, communication with faculty and observation of university departments could highlight commercial opportunities that a dedicated MATE team could explore under the guidance of faculty and the commercialisation office, VicLink.

This proactive model could work without ongoing input from academic staff, as the projects would have been generated within the MATE programme and therefore would be original, with no predetermined course of action. Teams would form in response to the results of this initial phase and would determine a course of action.

From the author's standpoint, MATE would seem the perfect conduit for ideas on interdisciplinary collaboration and development of academic commercialisation projects.

6.6 Unanswered questions and possible future research

Due in part to the accumulative nature of the 2013 MATE programme, this thesis does not provide a thorough analysis of the application of either Lean Startup or Design Thinking to the commercialisation of research. In order to fully understand the implications of each process, they would need to be included in the commercialisation process independently *from the outset*. Targeted use of the Lean Startup to support the work of existing research teams could help direct ongoing research towards commercial viability. Focused study of the Design Thinking process – as either a management technique or a product development process – could facilitate the development of creative and truly innovative enterprises across the university.

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APPENDIX 1

MATE GROUP REPORT

BY

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Submitted to Victoria University of Wellington

In partial fulfilment of the requirement for the degree of

Masters of Advanced Technology Enterprise

Victoria University of Wellington

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Chapter 1 Introduction

The purpose of this document is to provide background information to support the individual Masters of Advanced Technology Enterprise (MATE) theses of Ish Jimale, Liam Harker, Ian Walsh and Oliver Townend (referred to as "the team" and later "Hyv"). It is a chronological record of the team's work in 2013 on the NacreTech, Sound Concepts and Hyv projects and summarizes the key lessons learnt in order to provide context to the individual submissions. Team members contributed to different chapters based on their particular interest.

1.1 Pre Startup

The 2013 Masters of Advanced Technology Enterprise programme brought together graduate students from a broad range of disciplines with the goal of experiential learning through the development of commercial entities with roots in ongoing VUW research. The initial four week ATEN501 programme exposed the students to experts from both academia and business, and theoretical models, in particular the Lean Startup (Ries 2011) and Osterwalder and Pigneur's Business model Canvas (2010).

1.2 Project options

Following this introductory stage, the MATE participants were tasked with assessing four potential projects and forming teams to begin commercialisation. Research projects that have shown latent potential for commercialisation were pitched by "project champions", typically university academics leading ongoing research projects, who presented background information as well as an initial strategy for commercialisation.

1.2.1   Nacre

Professor Kate McGrath, School of Chemical and Physical Sciences, VUW

Professor McGrath's research has resulted in a patented method for the production of synthetic nacre ("mother of pearl"). This biocompatible material has promising applications in the biomedical field as an alternative to current synthetic bone grafting materials. Use as a void filling material in veterinary dentistry was proposed as a first market entry point from which to ultimately develop human orthopaedic applications. (McGrath, 2013)

1.2.2   Auti

Helen Andreae, VUW School of Design

Auti is a robotic toy designed to respond to and reinforce positive behaviours in children with autism. Auti was pitched to MATE as a working prototype that simulated the responsive functions of the device through remote control. Further research into the effectiveness of this type of treatment was being undertaken by the Helen Andreae as part of an unrelated masters program. (Andreae, 2013)

1.2.3   Sound concepts:

Natasha Perkins, Senior Lecturer, School of Architecture, VUW

Sound Concepts aims to develop and test forms that will help reduce reverberation times in interior environments. The commercialisation proposal centred on testing the viability of two existing prototypes: Pod, a freestanding breakout space for primary school classrooms, and TriForm, a hanging acoustic baffle system. Sound Concepts was further developed than the other potential projects and the prototypes had already undergone performance testing in school environments. (Perkins, 2013)

1.2.4   Dosimeter:

Dr. Grant Williams, Professorial Research Fellow, School of Chemical and Physical Sciences, VUW

Dosimeters are used to monitor and detect radiation doses and dose rates. The technology presented to the team focused on a novel method of detection and measurement using optically stimulated luminescence. The project champion had built a prototype and was interested in connecting with customers to test the effectiveness of the device in a real-world application. (Williams, 2013)

1.3 Team Formation: NacreTech

Having assessed the potential of the projects, with consideration given to the students' applicable skillsets, Jimale, Harker, Walsh, First and Townend formed a team around a common interest in the Nacre and Dosimeter projects. Professor McGrath's Nacre research (under the team moniker NacreTech) was ultimately chosen due to its clear development path and potential for wide-ranging commercial application.

1.3.1   Ish Jimale

Ish has a background in both business and science, having graduated with double degree in biotechnology, management and international business from Victoria University. He has been working for the Ministry for Primary Industries in an information management role.

Ish's attention focused on the customer development process, including primary market research and building relationships with potential customers.

1.3.2 Liam Harker

Liam has a background in science with a strong focus on biotechnology. In 2012 he completed a postgraduate diploma in bioscience enterprise at Auckland University graduating with merit. His previous experience in early stage technology validation has helped him develop skills in intellectual property and market validation and market research.

Liam's MATE focus has been project management and market research.

1.3.3 Ian Walsh

Ian has a business background with a focus on communications and customer relations. Ian is a customer support representative and strategy intern at Trade Me Ltd as well as being involved in the start-up community in Wellington, including Start-up Weekend and the Lightning Lab, New Zealand's first digital accelerator. He is particularly interested in customer development, primary market research, as well as marketing activities including brand development.

1.3.4 Naomi First

Naomi has a background in business and consulting, specifically strategy, planning and organizational design work for public sector clients, as well as experience in management, marketing and business development

1.3.5 Oliver Townend

Oliver brings experience in industrial design, construction and small business operation. Following his design degree at Massey University Oliver moved into residential building to gain detailed insight into a vital industry, with the intent to apply his design skills at a later stage. In the MATE programme Oliver's focus is project management and product development.

Chapter 2 NacreTech

2.1 Project Background

The first commercial application proposed for synthetic nacre is an injectable dental gel for veterinary use, suitable for filling the void created by tooth extraction. Finely ground nacre powder would be loaded into a biocompatible gelling agent with appropriate setting characteristics to create an integrated gel that would harden rapidly in oral applications. The hypothesis is that the nacre gel will protect the extraction site, thereby preventing infection and reducing healing time. Over time the gel will be resorbed and the osteoconductive properties of nacre will allow the growth of new bone and maintain structural integrity of the jaw.

2.1.1   Bone Augmentation

Filling the void left by tooth extraction is an example of the use of bone augmentation (commonly referred to as bone grafting). In humans, this procedure is relatively common in order to repair the jaw bone and provide support for prosthetics (false teeth). Bone augmentation procedures are relatively common in both human and veterinary orthopaedic surgery, with uses ranging from dental implants to joint fusions. The majority of these procedures use grafting material taken from a healthy site within the patient (autograft), commonly the iliac crest. This requires additional invasive surgery and increases patient healing times. Another option is to use material from a donor of the same species (allograft) which is heavily processed to remove all organic material and prevent rejection.

A bone graft substitute can augment or even replace the need for an autograft, reducing the negative effects on the patient. Synthetic substitutes have been on the market for approximately twenty years, however to date no synthetic material has achieved all of the attributes of an autograft.

Ideally, a bone graft substitute will achieve:

- Biocompatability – the ability to be in contact with living tissue without an adverse effect

- Bioresorption – the material will break down in the body and not require removal

- Osteoconduction – the material acts as a scaffold around which new bone can form

- Osteoinduction – the material actively stimulates the growth of new bone tissue

- A similar physical structure to bone

While most current substitutes achieve osteoconductivity, very few achieve osteoinductivity. It is this quality that synthetic nacre must strive for.

The market for bone grafting materials is large at $1.9 billion and is forecast to continue growing for the next 25 years in line with ageing populations. Performance is valued more highly than cost in bone grafting materials, particularly in the human market where the material itself represents only a small percentage of the overall cost of procedure.

2.2 Team Roles

At this early point the team had yet to split into specialised roles and members were focussed on a sole task: the validation of the potential of synthetic nacre based products in veterinary dentistry.

2.3 Market Research

This validation required a combination of primary and secondary research. Using Lean Startup methodology the team set about gaining an understanding of the veterinary dental market.

2.3.1 Primary Research

Following Steve Blank's "get out of the building" technique (2007), the team sought direct interaction with the proposed market. Through conversations with specialist veterinarians we set about to establish the "pain" or level of need for synthetic fillers in veterinary dentistry.

WSAVA Conference
On Friday 8 March 2013 Oliver Townend attended the WSAVA (World Small Animal Veterinary Association) Annual Congress in Auckland, specifically to gain an insight into the global veterinary industry and make contact with specialists in veterinary dentistry and orthopaedics.

Generally veterinarians, both generalists and specialists, understood the NacreTech concept. It quickly became apparent that while veterinary dentistry is not a large market, there is strong interest in effective bone augmentation products for use in orthopaedic surgery. At present bone augmentation in animals is not common since current products are ineffective and provide no measurable benefit over the lifespan of the animal.

Key Points:

- Not one of these specialists immediately identified major flaws in what we were proposing, although the introduction to the technology was brief, and based on some early predictions.

- While New Zealand veterinarians tend to be generalists, internationally animal dentistry is a growing specialisation.

- There is growing recognition that dental health has a significant effect on overall health, and that while animals may not display obvious symptoms serious issues may be developing.

- A nacre based bone augmentation product MUST have high osteoconductivity and MUST be absorbed by native bone cells fairly quickly in order to provide a significant benefit over existing products. It cannot be an inert filler.

- Our product would need to be simple to use and inexpensive, allowing us to market it as having significant benefits for limited extra effort. This will enable the product to gain traction in a market that is currently happy without it.

Massey University

On the ninth of April 2013 the team travelled to Palmerston North to meet with veterinarians at Massey University. We were able to speak with two specialists with experience in bone augmentation:

- Dr Andrew Worth: Senior Lecturer in Small Animal Surgery (Orthopaedics)
- Dr Angus Fechney: Companion Animal Veterinarian (Dentistry)

Both expressed concerns over the lack of need for void fillers in veterinary dentistry, as they very rarely use these types of products. Generally if they are forced to remove a tooth from an animal it will heal naturally without the use of any additional products.

Andrew and Angus shared insights into the current use of bone graft substitutes, a market which they felt was saturated by products that did not deliver on their promised performance. Most of the industry uses autografts (tissue from the patient itself) or allografts (tissue from a donor of the same species) which have significant advantages over synthetic products - specifically the osteoinductive properties of natural bone which current synthetics cannot deliver.

Estendart

While in Palmerston North we took the opportunity to meet with Dr Alan Alexander from Estendart, a company operating within the Massey University Research Park which specialises in animal trials for development of medical products. The purpose of this meeting was to gain an understanding of the in-vivo (live animal) process, particularly to inform the in-vitro (laboratory) tests required initially. This process would ultimately test the safety of synthetic nacre as a bone grafting substitute.

The result of the meeting was a focus on in-vitro safety trials for synthetic nacre to prove that the material was non-toxic to living cells. Only after achieving successful results could we begin to look at setting up in-vivo tests in animals.

Phone interviews:
In February and March 2013, the team contacted eleven veterinary professionals within New Zealand including five specialist veterinary dentists.

2.3.2   Secondary Research

Most of the quantitative information gathered concerning market size, competitive products and market trends came from secondary research via industry reports and online databases, which provided an insight into the current state of the veterinary dentistry industry. The team was quickly able to determine that multiple competitors existed and was able to compare their products with nacre. It was established that existing void fillers belonged to a larger market of products called "bone graft substitutes" and had been relabelled or modified to be used in veterinary dentistry rather than developed specifically for this application.

2.4 Results

2.4.1   Bovine

Our research determined that this is not a viable market as dental health is not an issue in cows. Chewing cud effectively cleans the teeth and gums and prevents tooth decay. Cow's teeth continue to grow and to be ground down throughout the life of the animal. Tooth extraction is rare and when it does occur the site heals without issue.

2.4.2   Equine

Horses have a very different dental anatomy to humans. As with cows, the teeth continue to grow and are constantly ground down by mastication. When a tooth is removed the surrounding teeth will move to fill the space created and the forces involved are tremendous. According to Elizabeth Thompson from Blue Mist Equine Dentistry, if a material was implanted into the jaw it would need to have the strength of titanium to withstand the pressure of the other teeth. Infection post extraction is not a problem. Horses tend to easily react strongly to foreign bodies (for example

calcium carbonate) in the mouth, and their introduction may lead to additional complications.

2.4.3 Canine and Feline

Dogs and cats have dental anatomies much closer to those of humans. Companion animal dentistry is a relatively new but growing field as pet owners become more aware of, and are prepared to spend more on their animal's oral health. There have been marketing campaigns from both veterinarians and producers of dental health products to promote dental health awareness amongst pet owners.

In light of this information, the companion animal market was selected as the most suitable application for nacre as a dental filler.

Further exploration into this market revealed that while dental fillers were indeed used in the companion animal market, the number of veterinary dentists who use dental fillers following tooth extractions is extremely small. In fact, in most cases the resulting cavity was left to heal by itself without complication. Of the eleven veterinary professionals we spoke with, only two used dental fillers and they did so only when complications such as severe infection or trauma to the jaw bone were involved.

2.4.4 Key findings

Our research into the veterinary dental market has indicated that

- Dentistry in livestock (equine and bovine) is a small market. On those occasions where tooth extractions do occur there is no requirement for a filler or bone augmentation product.

- Dentistry for companion animals internationally is a developing market that is expected to continue to grow. However generalist veterinarians, who perform the majority of dental work on companion pets, rarely use a socket filler or bone grafting material following tooth extraction as sites usually heal well without the use of any specialised materials.

- The use of dental bone augmenting materials tends to be restricted to 'premium' veterinary practices that specialise in dentistry, of which there are few. Even in these practices void filling is often considered unnecessary as the introduction of a foreign body may exacerbate the condition.

- There is an abundance of products on the market that can be used for void filling.

- There are some oral conditions in animals where bone grafting material are more commonly used by the surgeons e.g. fracture repair and oral-nasal fistula. In these cases an integrated gel is likely to hinder the repair process.
- An ideal dental bone grafting material requires the following characteristics:
  - An osteoconductive matrix or scaffolding to support bone growth
  - Osteoinductive factors that stimulate and recruit host mesenchymal cells
  - Osteogenic cells that survive transplantation with the potential to differentiate and stimulate the various phases of bone formation
  - Structural integrity to ensure the graft won't collapse or be displaced

2.5 Pivot from Veterinary Dentistry to Veterinary Orthopaedics

In response to these findings, the team decided that veterinary dentistry is not a sufficiently large market for continued focus. Veterinary orthopaedic surgery offered a much better market entry point through the use of synthetic nacre as a bone graft substitute.

2.6 Pearl Seeding

As an alternative to medical applications, the team briefly explored an application of nacre to seed pearls in oysters. Currently, pearls are artificially created en masse by placing a "seed" inside of the shell of an oyster. The oyster then coats the seed in nacre to create a pearl over a period of time. Generally these seeds are pieces of mussel shell that are shaped into spheres. Larger implants are harder to come by as they require the use of mature shellfish with thick shells. These are not abundant given current practice of harvesting shellfish while they are still comparatively young. It was hypothesised that synthetic nacre could be used to create these larger implants.

Exploration of the market revealed that the pearl industry has recently undergone a dramatic shift that has reduced the overall production of traditional oyster grown pearls. Chinese pearl farms have developed a method of growing multiple pearls within fresh water mussels, greatly reducing the cost of producing high grade pearls and dramatically affecting the demand for seed material.

In light of this information it was clear that the solution offered by nacre was in the process of being phased out and would unlikely be needed in five years. The team made the decision to suspend research into pearl seeding at this point.

2.7 Summary: Lessons Learned

- Exploring customer need can often yield new information, leading to changes in product requirements and specifications. Be prepared to change.

- Effective communication between all those involved in a project like this is extremely important. Everyone should be involved and on the same page.

2.8 Conclusion of NacreTech

The following is an excerpt from the NacreTech final report, presented to Professor Kate McGrath on the 6th of May, 2013.

> There is resounding evidence that current methods of treatment following a tooth extraction within the veterinary dental market are deemed acceptable. If and when fillers are required there are adequate products already in the market with features that include biocompatibility and osteoconductivity.
>
> The wider field of synthetic bone grafting does appear to have some potential. There is strong evidence of a yet unmet need for a synthetic product that has all of the qualities of an autograft. There is a significant international research and development effort focused on developing this 'gold standard' product.
>
> The ability of naturally occurring nacre to support the regeneration of bone has been demonstrated in published research trials on animals. If it can be shown that these properties can translate to synthetic nacre this material could be a promising candidate for use in bone grafts. This has applications for surgery on both humans and animals.
>
> To enter the bone graft market, synthetic nacre would need to prove that it matched the properties of leading synthetic bone grafting alternatives. Once these properties have been verified, product development would be required to ensure the development of a viable product in forms that would meet market need, while being cost effective. Even with the right product, entry into this very crowded market would not be easy without the right partners and relationships in place.
>
> Based on our understanding of the materials research to date, NacreTech do not believe that the testing necessary to prove synthetic nacre's properties could be completed within the timeframe of the 2013 MATE programme. The NacreTech team has therefore concluded that product development at this stage is premature.

The NacreTech team recommends that work is not continued on the specific application of synthetic nacre as gel-based dental filler due to the low use of comparable products. Also, that testing is undertaken to assess the following properties of synthetic nacre before product development commences:

- biocompatibility

- level and speed of bioresorbtion

- level of osteoconductivity

- level of osteoinductivity

- structural integrity and strength.

Once testing has confirmed that synthetic nacre has the required properties, either Viclink or a future MATE team pursues product development and commercialisation.

Based on these conclusions the NacreTech team ceased work on the project, presented our report to the project champion and handed responsibility back to the researchers. Synthetic nacre shows strong promise for application to veterinary orthopaedics if it can be shown to meet the needs of the bone augmentation market. It is our hope that the technology will be picked up at a later stage for continued development.

At the completion of the NacreTech project, Naomi First made the decision to leave the MATE course for personal reasons, reducing the team to four.

Chapter 3 Sound Concepts

3.1 Background

School of Architecture Senior Lecturer Natasha Perkins has developed a series of products designed to reduce reverberation times in interior environments.

Technical research was undertaken during 2010-12 to develop and produce prototypes of a freestanding children's breakout space (POD) and an acoustic baffle system (TriForm) for pilot installation and testing in primary schools and community halls.

Companies that would use the products include architects and specifiers for commercial fit-out, schools, and council halls to upgrade acoustic performance of interior environments – this could be on a national and international level. Previous offshore market research with architects has shown a need for 3D acoustic forms within commercial and learning spaces.

3.1.1   Pod

Pod was designed as a freestanding acoustic product for use in primary schools. It is made up of hexagonal panels that form a structure for children to occupy and play in. The panels themselves are formed from a polyester acoustic material produced by Autex Industries.

FIGURE 6: POD

The product was designed to act as a passive absorber of sound within a classroom environment while providing a calming, quiet space to aid children, in particular those with central auditory processing disorder or other hearing impairments.

3.1.2   TriForm

TriForm is a series of individual quadratic components, joined together to form a geometric acoustic baffle. A system of these baffles can be incorporated into the ceiling space of classrooms and public spaces.

FIGURE 7: TRIFORM

With its suspension flexibility, the intention of TriForm was to be used in large quantities to absorb a range of sound frequencies and reduce reverberation in interior spaces.

3.1.3   Return on Science

Prior to the MATE team's involvement, start-up consultant Michael Elwood-Smith was contracted by VicLink to carry out a market scan on Sound Concepts to identify its commercial potential. He presented his findings to the Return on Science investment committee, a national research commercialisation programme that works with technology incubators to bring new research to market from universities, research institutions and private companies. His findings are summarised below:

- A growing global market is identified for products that improve room acoustics and are aesthetically pleasing.

- The combination of acoustic performance, aesthetic design and eco-friendly products is of interest to potential customers and users, and fits with market trends.

- There is potential added-value for a software product/service to support the application of products within rooms, which is likely to be used by architects.

- The best and first product/market fit and therefore the scalable business model is not yet clear.

- Commercialising this work would best suit a start-up company where the first objective is to discover the true market potential, product fit and scalable business model.
- Both current forms appear to have potential market fit. However, further work is required to define the initial target markets and the appropriate product to suit that market.

3.2 Objectives

The MATE team was expected to continue this assessment of the viability of Pod and TriForm in the school market. We were also given the opportunity to explore other markets to see if these products could be of benefit to a paying customer.

As a team we sought to broaden our exploration of customer needs rather than trying to fit a product into an existing market. We sought to better understand whether there is a need for acoustic products in various markets, how much of a pain point exists, find out how these prospective customers were currently addressing the issue and how much they were willing to pay to solve it. This broader approach saw the team undertake validation activities across multiple markets, as well as speaking with architects, designers and acoustic consultants.

3.3 Refined Team Roles

3.3.1 Ish Jimale

Ish concentrated on validating the market for the Sound Concepts products. The main objective was to collect market data that will be used to drive decision making processes.

3.3.2 Liam Harker

Liam tested assumptions about the products appeal and performance in the market by engaging customers and industry experts in phone and face-to-face interviews.

3.3.3 Ian Walsh

Ian focused on market validation efforts. He was responsible for contacting school principals and property managers around the country.

3.3.4 Oliver Townend

Oliver investigated the supply chain and manufacturing processes of the current products and explored potential alternatives.

3.4 Sound Concepts for Schools

The primary goal of this stage was to assess the commercial potential of Pod and TriForm's use in school classrooms, as proposed by the research team.

3.4.1 Market Validation

As an initial scan of the educational market, we canvassed school property managers across the country, in primary, immediate, special needs and secondary schools across the state and private spectrum. We made phone calls to managers asking them to express their problem, rather than trying to sell them our solution. We asked the following questions.

- Do you take acoustic performance and noise control into consideration when fitting out the interior of a classroom?

- Have teachers expressed concern about the level of noise in classrooms?

- What is your main motivation for improving acoustics in a classroom?

- How do you currently address this issue?

- What types of products do you use?

These questions allowed the customer to elaborate on needs, problems and issues that they deal with daily, and gave structure to the conversation. After interviewing twenty seven decision makers in schools, patterns began to emerge. Here is a sample of the feedback we received.

- Acoustics are taken into consideration when fitting out classrooms, though this is usually left up to the architect.

- Some teachers have expressed concern over interior acoustics and excessive noise but these issues are not considered a major problem on the whole.

- Current solutions include soft furnishings, acoustic ceiling tiles, carpet, pin boards.

- One respondent had recently installed Autex acoustic wall coverings, stating that it was "*very expensive*" but the "*best money ever spent*!"

- Amplification (speakers and audio equipment) are used with varying success.

- For many schools, interior acoustics are a "nice to have" but with limited budgets priority must be given to seismic strengthening and other costs.

- There is growing awareness of the needs of children with hearing problems.

- Noise generally only given serious consideration in "special use" spaces: workshops, music rooms etc.

3.4.2   Summary of the School Market

- The acoustic environment of a classroom is a concern and a need that property managers consider when refurbishing.

- Private schools (primary and secondary) more often have the funds to improve the acoustic environments of their classrooms. However, this budget is usually spent on existing solutions such as acoustic ceiling tiles and wall linings.

- State Schools (primary and secondary) do not have large enough budgets to invest in acoustic products as they have other concerns.

- Although a need has been identified, there are dominant competitors in this space. In particular, Autex in the New Zealand market.

3.4.3   Pivot

Our research determined that the market for specialised acoustic products in schools is small and often restricted by budget constraints. The team began exploring alternative markets for Sound Concepts designs, identifying commercial office spaces as having significant potential. An increasing number of organisations are switching from traditional offices to more open plan, decentralised work environments. This can be to encourage collaboration, promote good work habits and to save costs. Acoustics in this environment are consistently ranked in the top three "most important considerations" by architects when fitting out new office spaces. Many organisations introducing open plan offices have substantially larger budgets for acoustic issues than schools. In light of the team's preliminary findings, we decided to focus on open plan offices as a market entry point for Sound Concepts.

3.5 Sound Concepts for Offices

The team began exploring this direction with the goal of identifying the key requirements of office spaces, in order to inform the development of further Sound Concepts designs.

3.5.1   Market Validation

Preliminary investigations into the commercial office market identified that workers in open plan offices consider noise to be a substantial problem. We spoke to office managers on the phone to ascertain the importance of reducing sound reverberation and to learn how they were currently addressing that issue. We discovered that office managers do actively consider the acoustic environment in the office and use a range of acoustic products to manage it.

Key findings:

- Significant acoustic consideration is given to meeting rooms, quiet spaces and video conference rooms, motivated by the need for client confidentiality and general staff productivity

- Acoustics accounts for roughly 5% of fit-out costs

- Current solutions include soft furnishings, perforated wooden wall panels, in-wall insulation, ceiling tiles, acoustic blankets.

- Acoustic engineers are sometimes contracted at significant cost to assess the requirements of spaces

- *"It all comes down to one person, the marketing guy next to the accounts guy."* Nigel Lloyd, Acoustic Consultant, Acousafe Consulting & Engineering Ltd

The following are case studies which provided key information on the feasibility of Sound Concepts in office spaces.

3.5.2 Pelorus Architecture

We interviewed Don Taylor on August 30 2013. Don is a 'friendly contact' introduced to us by Professor Sally Davenport, one of the MATE supervisors. Up to this point, most of the interviews with commercial architects were conducted by telephone. We now had an opportunity to speak face to face, which we found is the best way to get essential information in order to steer the team in a particular direction.

One of the key insights from this meeting was the confirmation that there is a need for customisable solutions that can create semi-private spaces within offices. Fuelled by the growing number of organisations switching to open plan offices, architects face the challenge of creating a range of work environments within a single space. In particular Don articulated the challenge he faces when trying to create semi-private spaces where employees can take phone calls, collaborate and have discussions without disrupting colleagues.

Don's current arsenal for the creation of "breakout spaces" consists of either constructing bespoke solutions or specifying soft furniture. Depending on an organisation's budget, bespoke jobs can range from low cost meeting spaces constructed from readily available materials, all the way to "showpiece" jobs that can cost in excess of $30,000.00. The approach is limited by several factors:

- The lead time to get them built

- Requirements for sprinklers, lighting and air flow

- Difficulties in making changes to the structures once installed

- Added cost of restoring the premises to its original state at the end of the lease.

When quizzed about an ideal solution, Don spoke about the need for a product that incorporates an element of standardisation, which he can then use with his design expertise to add a customised dimension. He envisioned an easily assembled frame to which he can apply various materials, resulting in customised partitions. The ability to use different materials was particularly appealing to him given the distinctive needs of different organisations. For example, organisations with limited budgets are more likely to cut costs by opting for simple, non-acoustic materials.

3.5.3 TwentyTwo Property Advisors

Over the course of the Sound Concepts project we spoke to several property advisors. These organisations often play a key role in all things "property". For instance, when an organisation is moving into new premises or renegotiating lease terms, contacting a property advisory firm is often the first step. Sitting on top of the property "food chain", these companies can negotiate lease terms and building modifications. Importantly for us, they have a wide range of industry contacts including with architects, designers, project managers and contractors. In essence they oversee the commercial office fit out process and bring together different parties as required.

Duncan Mitchell from Wellington company TwentyTwo Property Ltd is someone with whom the team built a close relationship with over the course of the Sound Concepts project. Duncan has shown real interest from the beginning of the project, partly because his firm conducts research into improving work environments. Duncan provided us with well-balanced feedback that took into account the various aspects his company must consider. In helping us validate the feedback from Pelorus Architecture and others, Duncan alerted us to the following key considerations:

- There is often a 'disconnect' between what architects perceive as an appropriate solution and the core requirements of the end users. This leads to too many custom solutions not being used as intended. Duncan recalls one incident where a firm invested substantial amount of money in a bespoke "creative space"; only for it to end up being used for people to eat lunch.

- He stressed that there is a need for a more customisable, reconfigurable way to meet changing business needs given the turbulent climate that most

industries are currently experiencing. Further, any potential solution must be affordable.

- There are a few solutions already in the market, but most are very expensive and are thus not accessible to many organisations.

- Furniture solutions such as high-backed couches have their limitations, particularly in the lack of customisation. The cost per unit (approx $7000) is not outrageous but the average organisation would need 3-5 units, which quickly escalates the total investment.

- Don advised us that the best people to talk to are the end users and property managers.

- He offered to trial prototypes with some of his clients.

3.5.4   Summary of the office market

We had validated our assumption that commercial office environments require acoustic treatment, however we had not validated whether Sound Concepts products would satisfy the customers' requirements.

The findings above demonstrate the need for acoustic products in certain areas such as meeting rooms and waiting areas. As there is significant competition in the field of acoustic ceiling tiles, the team decided to focus on customisable, versatile products for creating meeting spaces at *ground level* in open plan offices.

It was at this point we explored the potential for an adaptation of the Sound Concepts prototypes, to see whether it could be used to produce a meeting room shell or "room within a room" with reduced sound reverberation. This product would also act as a visual barrier, adding to the aesthetics of the office. We refined the focus of our research to the use of "breakout" spaces or semi-private meeting areas, which allow office workers to get away from their desks to have informal meetings.

3.5.5   Pivot

We understood the greatest need was to develop meeting spaces or "rooms within a room", but that the acoustic capability of the product could not be the defining value of our proposition to customers.

Having focussed on 'design' and 'aesthetic appeal' during the market validation, we now shifted our focus to a 'design-led acoustic solution' rather than simply acoustics. This strengthened our core aim of providing an attractive, productive space that would have some noise dampening qualities.

3.6 Sound Concepts: Hyve

Based loosely on the formed polyester structure of the Pod and TriForm concepts, and taking into account the market data we had gathered, we developed a series of designs to demonstrate a new concept: we sought to develop an aesthetically appealing breakout solution for office spaces; further, we sought to develop a product that was informed by customer feedback. We called this product Hyve, pronounced hive.
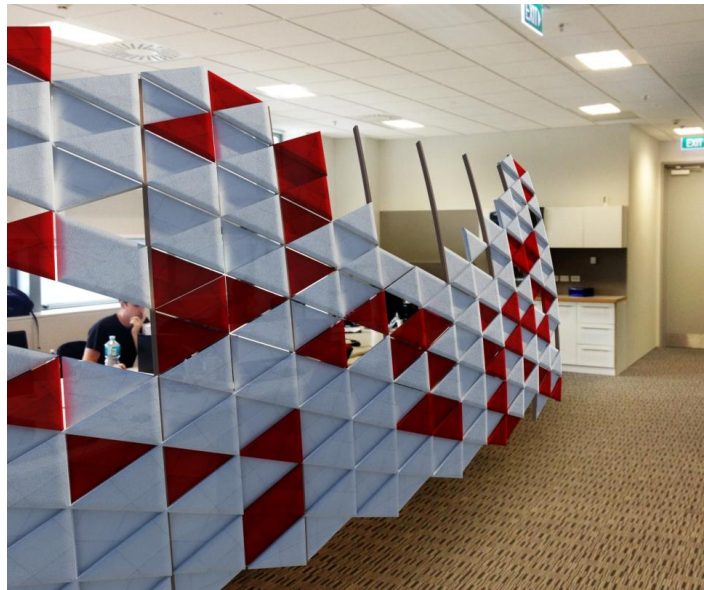

FIGURE 8: HYVE PARTITIONING

FIGURE 9: HYV SCREENS

3.6.1   Return on Science

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The team returned to the Return on Science investment committee on August the 15th 2013, for guidance and potential funding through "Stage 1" of their commercialisation process. This would support further progress towards product development. We presented the following findings to support the case for developing Hyve.

- Office managers and workers are interested in 'pop up' meeting rooms or breakout spaces within leased offices and at conferences and tradeshows where people are looking for a sense of privacy (visual and aural) to conduct meetings in crowded, noisy spaces.

- It is believed that such spaces can be designed and built with the PET material forms and framework at a competitive price, with good margins, and could find a significant market.

- The core value in the work is in product design rather than acoustic performance

- The raw materials and manufacturing rely on third parties.

Upon review, the committee felt that there was too much completion in the office furniture market and that the project lacked adequate "scientific" involvement (an important factor of their assessment criteria). The committee was concerned that there was no unique selling point that would set this concept apart from more established commercial office furniture suppliers. The lack of proven acoustic gains also caused concern. As a result the Return on Science committee decided not to fund the continued development of the project.

3.6.2   Trade Me

The team arranged to meet with Michael O'Donnell, Head of Operations at Trade Me, as they will be changing offices in 2014 and refurbishing three floors of office space. Michael arranged for all the parties involved in the new fit out to meet so that the team could ask them direct questions and gain insights into the refurbishment process. The main aim of the meeting was to understand:

- Who the key decision maker is within the group?

- Who selects the interior products, including acoustic products?

The meeting brought together Herriot + Melhuish Architects, L.T. McGuinness Ltd (construction contractors) and Trade Me's office managers. During the meeting we gained specific feedback about our direction, our approach and what we would have to do in order to make our proposition valuable to them as customers. We also discovered that the key decision maker in this process was the Head of Operations.

However, he is still influenced by the recommendations of the architects and interior designers.

With this information we were in a better position to target our market validation efforts on senior executives rather than office managers. We also learnt that understanding the needs and motivations of architects is vital as they are key influencers in the customers' purchasing decision.

3.7 Supply Chain and Manufacturing Investigation

The primary goal of this stage was to understand the process currently used to produce the Sound Concepts prototypes, and to determine whether this method is appropriate for large scale manufacturing.

3.7.1 Calvert Plastics

The Pod and TriForm prototypes have been manufactured by local company Calvert Plastics, specialists in thermoforming of plastic sheet. On May 30th 2013 we met with Darryl Pickering to learn about their manufacturing process. Calvert are a manufacturing company and are not experienced or interested in directly marketing their products. They currently produce a range of formed polyester wall panels made from Autex material that are sold back through Autex.

- Calvert are looking to find new distribution channels (other than Autex) for their products

- They're conscious of the fact that Autex could manufacture in-house if they wanted to.

- They encouraged us to look into international markets immediately

Production
Sound Concepts designs are produced by heating and pressing (thermoforming) flat polyester sheet in a three-dimensional mould. The process is labour intensive and not currently set up for large volume production. If demand is high enough Calvert will purchase a new machine to dramatically improve the production times.

- Current machine setup can produce approx one unit every three minutes.

- New machinery would do exactly the same process but with higher level of automation and faster turnaround, potentially two at a time.

- New machinery built specifically for this process estimated to cost $75,000.00

Custom Fit outs

In 2012 Calvert Plastics were contracted to produce custom panels for the ceiling of the Air New Zealand Koru lounge at Christchurch Airport. Rather than manufacturing in their Lower Hutt factory they built a mobile jig to form the panels on site which made transport much more efficient and prevent damage prior to installation.

- Air NZ Koru lounge was essentially a prototype for future custom fit outs.

- Custom fit out more profitable for Calvert as they can charge for design, prototyping, building jigs etc.

- Price obviously acceptable as Air NZ is in talks to do same with next Koru fit out.

- While these jobs are profitable, they are few and far between.

- They need a network of architects, especially from big firms such as Jasmax, to specify these fitouts.

Furniture

- "*This stuff is good for furniture as long as you don't touch it*" – Polyester acoustic material is hard to clean.

- White surfaces are not advised as they look dirty very fast.

- Calvert are maintaining a focus on wall and ceiling panels, rather than sculptural forms

3.7.2 Alternative Production

Initial investigation into production methods was unsuccessful in establishing a viable alternative to Autex material and thermoforming to produce Sound Concepts products. Sourcing the raw material directly from manufacturers in China was considered however this would require large scale production to be feasible and if this scale was achieved production of the components would likely be offshore.

3.7.3 Anderson Design Meeting

Representatives of the team met with Ian Anderson of Anderson Design, specialists in the construction of custom fit outs for displays and exhibitions. Ian recognised the trend of communal "breakout spaces" - in fact Anderson Design have produced custom spaces in the shape of giant rugby balls for the New Zealand Rugby Union. Companies use commission pieces such as these to create a brand-specific atmosphere. Acoustics are a consideration. Andersons have been in discussion with Autex Industries about use of their materials, though acoustics are only one of many factors.

Ian believed a breakout space such as the Hyve office version could easily be manufactured "custom" but would be expensive and he didn't see any market for mass-produced units. At the likely price level businesses would rather have a unique product - something that no one else has.

3.8 Summary: Lessons Learned

In the process of investigating open plan offices we interviewed approximately sixty people including office workers, property managers, architects and manufacturers to learn about the issues they face and their requirements for a product that will address them.

- Many people are not satisfied with their current open plan work environment.
- The majority expressed interest in a system that creates semi-private spaces within open plan offices
- The ideal solution should be versatile, simple to setup and affordable.
- It should control noise and provide a sense of privacy.
- Architects have considerable influence on product specification.
- The market for polyester-based acoustic sheet is dominated in New Zealand by Autex Industries.
- Aesthetics are important for some customers, but functionality is more important.
- Architects want better ways to improve acoustic performance of interior spaces.
- They are interested in a system that will improve their results without the need to hire acoustic consultants.

This feedback indicated an opportunity exists in open plan offices.

The Sound Concepts derived Hyve system could potentially address this opportunity, however:

- The concept was not considered sufficiently novel
- The level of functionality did not justify the predicted cost of production
- The aesthetics were polarising, indicating that it was best suited to custom installations rather than mass production
- Therefore, there was no product-market fit.

The team decided to set aside all existing prototypes and preconceived solutions and to build on the opportunity we had identified.

Chapter 4 Hyv

The team (now under the moniker Hyv) had a substantial body of information and a network of contacts with an interest in improving open plan environments. This put us in an excellent position to develop a market-driven solution. This required a shift in mindset from "technology push" to "market pull". A market driven approach would differ from the technology push we had experienced through the NacreTech and early Sound Concepts projects in several ways:

- Any product or solution would be developed in response to market requirements gathered through our research
- These market requirements would be refined through feedback into a product specification
- Specification would be refined through an iterative product development process

4.1 Targeted market research: Open plan offices

The team began by constructing a survey designed to empirically confirm the need for semi-private meeting spaces within open plan offices and to clarify their key requirements. We sought to quantify the information we had gathered thus far by re-surveying the contacts we had established during the phone survey process. We needed to determine the relative importance of the product requirements in order to distinguish between the "must have" and "nice to have" features. Further, we were keen to discover any requirements we might have missed during earlier interviews.

Based on our initial conversations, we now asked: "How important are the following attributes?"

- Simple to install, not requiring building consent, contractors or major construction.
- Lightweight (can be moved easily by one person)
- Reconfigurable for use in a variety of different spaces
- No higher than 180cm to avoid the need to move sprinklers or to get building consent.
- Freestanding without the need for additional supports such as bolts or ceiling suspension.

- Have acoustic properties that dampen noise

- Data/power options built into the structure of the product

- New Zealand made

- Environmentally friendly

- Cost effective

4.1.1 Results

Our contacts were asked to rank the importance of each product feature and how it would affect their purchasing decision on a scale of 1-10, with 10 being a feature of great importance or value. This provided an understanding of which requirements would influence the customer when making a decision. The market requirements determined for a meeting room product with acoustic benefits were, in order of importance:

1. Simple to install (not requiring building content, contractors or major construction)

2. Freestanding without the need for additional supports such as bolts or ceiling suspension

3. No higher than 180cm to avoid the need to move sprinklers or get building consent

4. Data and power services built in

5. Acoustic properties to dampen noise

6. New Zealand made

7. Environmentally friendly

8. Lightweight (can be moved easily by one person)

9. Reconfigurable, for use in a variety of different spaces

10. Cost-effective

4.2 Conceptualisation

The team began work on a "green field" design, created from scratch in direct response to the requirements and feedback from our market research.

A concept was created in digital format that sought to address the user's requirements while achieving appropriate cost effectiveness, manufacturability and aesthetic appeal.
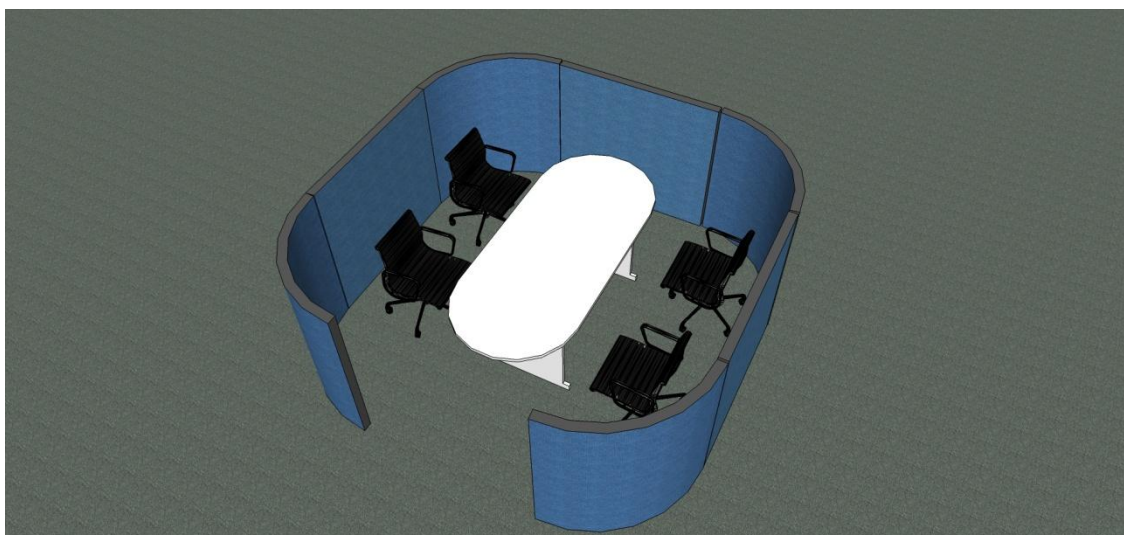
FIGURE 10:HYV EARLY CONCEPT

This design did not initially include any material or process considerations as the primary focus was to address the functional aspects. The proposed system consisted of two basic panels, straight and curved, from which a variety of configurations could be created to suit open plan office users.

4.2.1 Refining the concept

In the next part of the survey we attempted to demonstrate our understanding of the requirements through our digital rendering. The questions we asked attempted to find out whether the concept addressed the problems outlined in the first survey. Moreover, we also wanted to know what aspects of this concept would stop customers from purchasing it and what they thought was a fair price range.

The majority of respondents did not think the concept captured the requirements in the first part; however a small subset of respondents liked the concepts, one of these being Creative HQ, this indicated a niche market that could be targeted with the first version of Hyv.

4.2.2 Creative HQ

Creative HQ is the Wellington region's business incubator, housing some of the most innovative start-ups identified for their potential high growth. We contacted their property manager, Rebecca Hill, to take part in our survey. Rebecca's feedback stood out from the rest; she indicated a strong correlation between our early concept and the requirements of the Creative HQ office. To find out why her feedback was so different, we followed up with a meeting at the Creative HQ office. We learnt that currently their work stations are separated into cubicles using aluminium-frame partitioning. Teams used a central table to host informal meetings and other collaborative activities.

Creative HQ is contemplating an open plan office when they relocate to a new office in 2014. They require an open plan set up with semi-private spaces that teams can use for meetings, collaboration and other activities, to avoid disruption to people working at their desks.

Rebecca expressed her need for an affordable, simply installed, customisable solution that can be configured in various spaces. She proposed an opportunity to fit-out The Lightning Lab (a three month business accelerator program which Creative HQ supports) to refine the product and provide proof of the concept's functionality. Following that, she foresaw potential for the team to be involved in the Creative HQ fit out in 2014.

4.3 Prototyping

Having assessed user responses to the digital concept, work began developing a full scale prototype that would allow interaction with the space and test its performance. Material and processes were considered that would allow the team to build this prototype, using an adaptation of Lean Startup Minimum Viable Product (MVP) theory, with the aim of gathering the most validated learning from the least investment. By quickly creating a full scale, low cost model that could be shown to, and interacted with, by users we aimed to quickly establish what aspects of form and function were most critical to the products success.

Cardboard panels were settled on as a suitable material for these early prototypes, as for a modest expense we could create lightweight, self supporting structures that were robust and easily modified. While initially cardboard was proposed purely as a prototyping material it quickly became apparent that it had some permanent potential, particularly as a substrate upon which to apply a range of finishes and coverings. The fundamental physical characteristics of the material are well suited to the requirements of the proposed system and its sustainability and recyclability fitted our ethical position as an enterprise.

4.3.1   DoubleEco cardboard panels

DoubleEco is a Wellington business that manufactures cardboard pallets suitable for freight and storage. Cardboard pallets can withstand large loads, do not require fumigation and can be recycled at the end of their useful service life. The corrugated card used by DoubleEco is locally manufactured from sustainably grown wood fibre and glued together with non-toxic adhesive.

4.3.2   Bending cardboard

The curved elements of the initial concept provided a point of difference and a degree of aesthetic variation to what was in effect a very simple panel structure. They were initially proposed, as mentioned earlier, with no consideration of how they would be

created. This provided a valuable experience in interdisciplinary product development for the team.

FIGURE 11: BENDING CARDBOARD AND THE FINISHED PANEL

Once again cardboard was well suited to this prototype development. By layering and glueing single layers of corrugated card around a mould (a concrete drain pipe) we were able to create a cardboard cylinder of the required dimensions which was then cut into quarters to create the curved corners of the prototype. This experimentation proved that curved panels could be created relatively easily with a dedicated production process (rather than outdoors round a drain pipe), while providing an indication of the labour (and therefore cost) involved in their creation. The laminated structure is robust and holds its shape well, and provides support to the attached straight panels.

Creating full scale pieces highlighted several issues with curves, in particular the bulk and difficulty of flat packing. Curves also created issues for connecting the panels and, and applying finishes and coverings.

The second generation of corner panels sought to address the drawbacks of curves while retaining the interesting aesthetic elements, improving configurability and allowing for flat packing. By cutting "V" grooves into a flat sheet of card we were able

to create corners that could be installed in a variety of angles, and laid flat for storage. These are also simpler to connect and cover and can potentially be produced using existing processes without the need for the custom built jigs needed for curved panels.

FIGURE 12: HYV1.0 MVP

4.3.3   Connections

As customisation, configurability and versatility were important user requirements, the connections that would secure the panels and coverings were crucial and complicated details. To connect two straight panels permanently is relatively straightforward; to do so with a permanently fixed covering (acoustic fabric, decorative prints etc) is also relatively simple. However, to create a connection from scratch that allows for a variety of configurations, repeated tool-less assembly and disassembly, using coverings of different materials and dimensions, while remaining cost effective, very quickly proved to be beyond the capabilities of our team.

Following this period of frustrated conceptualisation it became clear that we were getting ahead of ourselves. In order to test the concept most functional elements of the prototype could be faked or created in "bare bones" form.

4.3.4   Coverings and finishes

Coverings and finishes serve several purposes when applied to the proposed concept: firstly they allow for customisation and variety, allowing the basic units to be matched

to colour schemes, themes and branding of the user; secondly coverings can add to the performance of the system, particularly with regard to acoustics.

One of the most spirited team discussions of the year was about whether to cover the cardboard prototype before showing it to potential customers. On one side, some team members felt that that by exposing the bare cardboard structure to the customer we would run the risk of creating an impression of "cheap". Others had the view that covering the cardboard could prove unnecessary if the users did not see coverings and finishes as crucial. In the end the debate boiled down to how we presented the prototype and what we were attempting to test through this customer exposure - whether it was the aesthetics and perceived value, or the core functionality and user interaction attributes.

There was agreement that as completely uncovered panels the cardboard presented poorly. Debate continued over whether to disguise the structure (favoured by the marketing team) or embrace the materiality of cardboard and use its recognisable structure to our advantage (favoured by designers, but more polarising to the customers). A minor breakthrough came with the application of tape to the exposed edges, which hid the corrugations and prevented paper cuts. Suddenly the material began to come into its own as a presentable product.

4.4 Testing and Feedback

Having refined our concept and translated the validated digital renderings into a full scale prototype we were ready to show it to a panel of potential users.

In short, the prototype simply consisted of cardboard straight panels and flexible angled corner panels with taped edges and simple acrylic connections. By presenting it clearly as an early prototype and encouraging discussion around the pros and cons of the concept we sought to gather a vital body of information from the very people we hoped the system would appeal to.

FIGURE 13: INSTALLING THE HYV1.0 PROTOTYPE

4.4.1 Design School Workshop

The team organised a showcase event for our network of potential customers where they could experience the prototype, set up in a space at the VUW School of Design. Up to this point most potential customers had only seen the digital renderings. This was a chance to further refine the product's specifications. Customers invited to participate in the showcase were informed beforehand that this was not a presentation of a final product or even the final prototype. Rather this was a chance for them to tell us whether we had understood their requirements correctly. Internally, we also viewed this as an information gathering exercise by setting out the following key objectives.

- Refine the physical features including;
  - dimensions
  - height
  - configurability (and reconfigurability)
- Confirm the intended use and furniture fitting.
- Clarify performance related features i.e. acoustics, level of perceived privacy and whether this was fit-for-purpose in terms use as a meeting room.
- Clarify our understanding of what customers think of the cardboard material, covering options and functional add-ons (whiteboards, pin boards etc.).
- Get an indication of what price people would pay for a finished version.

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Key feedback on the Hyv1.0 prototype from the Design School showcase:

- It would be useful for cell phone calls and informal meetings of 3-4 people

- 1.8 metres good for visual privacy, although significant variation in responses

- Cardboard should be covered for a more "professional" look, although some users appreciated the funky cardboard aesthetic

- Strong interest in being able to move, reconfigure and store the product easily, though unlikely to occur frequently

- Some interest in users being able to customise a "basic" model

- Would suit informal furniture, coffee tables etc. Formal meetings can happen in the board room

- General acceptance of $900.00 for a basic "booth"

- General surprise at the decent level of acoustic separation between two showcase booths

4.4.2   Summary

The majority of the respondents expressed interest in the Hyv1.0 solution for informal meetings of roughly three people. The heights of the panels were deemed appropriate by the customers for the purpose of use. Participants also indicated the need for affordable pricing, which in the end was closely aligned with our cost predictions. Use of cardboard panels did not significantly detract from the concept, although covering it with a more aesthetically appealing material would be the preferred in a corporate environment, regardless of cost. Furthermore, the results point to the importance of the ability to reconfigure the system in various spaces, while also indicating the likely frequency rate of reconfiguring the meeting rooms is not as high as we had expected.

The results indicate a market opportunity for an affordable, simple to install and easily configured partitioning system that can be used to create a variety of semi-private meeting spaces. This market is characterized by organizations who are seeking a temporary solution, most probably while they look for a new, permanent office space. Based on our research there is a strong indication that this is a niche market. Therefore the current Hyv1.0 MVP is unlikely yield a highly profitable business that can employ all of the founding members on full-time basis. Exploring a more permanent solution based on the same concept is one interesting avenue to explore further as feedback indicates a bigger market. Extensive market validation is required to confirm if there is indeed a market for a 'permanent' version of Hyv.

4.5 Promotion and Branding

At this stage in the project we decided to execute some promotional initiatives, to actively spread the word about our team work. We created a temporary landing web page and experimented with using Google Adwords in an attempt to drive traffic to the site and to gain the email addresses of interested parties.

We engaged graphic designers Nandini "Nanz" Nair and Rose Wu from GoodieTwo to create a brand identity around "Hyv" for promotional materials and for use on social media sites.

The designers' brief focussed on our business entity and the customer benefit we sought to create – productive meeting spaces in busy environments - rather than branding a specific product. Our hope was that companies would eventually refer to a meeting room or meeting space as a "Hyv".

The team had discussed names that would suggest the benefits of the product (creating productive, quiet meeting spaces in busy environments), such as cocoon, hub, hive, shell, etc. We settled on the name 'Hive' as it suggested a productive working space, this subsequently became Hyve, then Hyv.

With the brand identity in place and the latest version of the prototype built, we began creating promotional materials to enable us to communicate the value to customers. After previous discussions with a number of potential customers, we understood what benefits, features and wording to use in targeting their interest. The designers created a brochure that sought to communicate the key benefits of the product. It also sought to catch the attention of customers through its innovative design. The brochure was folded in a way which resembled the panel product that we had produced. That enabled multiple brochures to be assembled to create variations of meeting rooms. This brochure achieved and demonstrated the core characteristics of the product: "flexible, lightweight, reconfigurable, versatile and simple".

FIGURE 14: HYV BROCHURE SHOWING BRANDING

4.6 Summary: Lessons Learned

- A user-centred, iterative product development process highlights whether the project is on the right track as early as possible.
- It is never too early or too late to include the customer in the product development process.
- Office workers and managers recognise value in what Hyv1.0 is aiming to achieve, however the form of the prototype has room for improvement.

Chapter 5 Hyv2.0

At present the Hyv project is based around the team's understanding of the need for furniture solutions that address issues of privacy and acoustics in open plan offices. Our prototype - Hyv1.0 - has shown potential as a concept for addressing these issues but requires substantial refinement.

5.1 Necessary next steps

In order to develop Hyv as a business, several key activities are necessary.

- Product Development: The current prototype requires significant development to become a product as either a cardboard MVP, or to develop into a more substantial "permanent" product. This development requires product design and engineering input.

- Customer Development: Refining the prototype requires continued development of relationships and communication with potential users who will ideally become customers.

- Business Development: As the project makes the transition from academic project to independent business, the ongoing structure of the entity must be determined. This relies on the commitment of the team to continue development, which itself relies on the underlying potential of the current concept.

5.2 Development Plan

As the team will no longer be students, the economics of continuing to develop the Hyv system take on new importance in 2014. The ideal situation is to generate early revenue to fund further development; this is where the minimum viable product technique becomes truly valuable.

5.2.1   The Lightning Lab MVP

The MVP, as distinguished from the prototype, is the first version of the product that we hope to sell to a paying customer. While the MVP may not include every function proposed it does include those features most critical to success in order to meet the requirements of a particular user (the early adopter) to the point where they are ready and willing to spend money on it.

The second annual Lightning Lab business accelerator program will run in Wellington from March to May 2014. As a short term entity incorporating a number of autonomous startup businesses the Lab has a fairly unique set of office fit out requirements. We are in discussions to provide cardboard Hyv1.0 breakout spaces to the Lab to allow teams collaborative spaces where they can get together for meetings, Skype calls or to escape their desks for a spell.

5.2.2 Tertiary Education Commission

Following the December MATE presentation the Hyv team were approached by Chris King, Manager of corporate support projects and services at the Tertiary Education Commission (TEC), to discuss the potential of trialling the Hyv1.0 prototype. Chris was intrigued by the concept and wants to explore options for an upcoming re-fit of the TEC offices. The new space will be largely open plan and will require configurable spaces to provide staff with space to collaborate. The trial has been confirmed for two months beginning in March 2014. This will allow a fresh look at the concept and the prolonged trial will allow the TEC staff to experiment with the system and provide valuable feedback which we can use to iteratively improve it.

Following this trial, we will hopefully have a completely validated concept specifically tailored to a particular customer. While this will not necessarily translate into a repeatable product the opportunity to create part of the TEC fit out would be a revenue generating process that could ultimately support the continuation of the business.

5.3 Manufacture / Licensing potential

Should the TEC trial prove successful, the team will look to outsource production of the product. As a startup business Hyv lacks facilities and equipment for in-house manufacture. Further, the skill sets of the team members are better suited to validation, research and sales than manufacture.

5.3.1 Formway Design Connection

We have established a relationship with Formway Design, a local business who have built a global presence in the field of furniture design. Formway no longer manufacture their designs in house, instead licensing them to established international manufacturers and thereby gaining support and exposure to a global market. This is a hugely relevant model for us as a business as we would seek to follow a similar path in order to broaden our market without going head to head with established players. Formway have offered to provide feedback from a mentorship position for the ongoing product development work. This is invaluable experience and further reinforces the learning and process we have undertaken through the

MATE programme in taking a concept from academic roots towards commercial realisation.

5.4 Texus Fibres Collaboration

Through VicLink Hyv came in contact with Timothy Allan of Locus Research, a Tauranga based market research and product development company. Timothy is on the board of Texus Fibres, a manufacturer of non-woven coarse wool fabric (felt) who are looking to find applications for their material.

As well as being a locally produced renewable material with a high level of aesthetics, Wool has excellent acoustic properties and the potential for passive air filtration, meaning that it has the ability to trap and store harmful vapours which are off-gassed by some building materials and furniture.

Initial market validation has shown that there is growing awareness of issues around air quality in response to sick building syndrome, and by combining our concept for highly reconfigurable office furniture with acoustic control and improved air quality we believe we have a unique value proposition with wide ranging applications, however this is a hypothesis that is yet to be fully tested.

5.4.1 Tech Jumpstart Summer Project

We have a Memorandum of understanding with Texus fibres for material supply and process assistance to develop a prototype based on our market research that will explore the use of wool fabric in acoustic furniture. Our work will include exploration of methods of forming Texus material into rigid three dimensional structures that could be built into self supporting structures, applied as panelling to ceilings and walls or used in conjunction with the Hyv1.0 system to improve the acoustic performance.

This work is ongoing thanks to a grant from VicLink and KiwiNet via the Tech Jumpstart summer programme. This funding has allowed us to engage the services of recent graduate industrial designers James Bennett and Lucy Mangin to work on the Texus collaboration and fine-tuning the cardboard prototype.

5.5 Overall Viability

Our research has shown that there is a market driven opportunity to develop furniture-based versatile work spaces for open plan offices. Potential users have expressed genuine interest in our concept; however significant development is required to get the current prototype to a finished product.

Our work has identified a business opportunity based on the design and manufacture of commercial furniture-based products. While this model has potential for growth it

is unlikely to present a case for significant investment and would be better suited to development by a founding team with appropriate technical skills.

Further product development in conjunction with established market contacts will determine the ultimate viability of the current Hyv concept. As the physical form of the product is refined, the viability of the business model will become clearer.

Chapter 6 Conclusions

6.1 Ish - Overall Lesson Learned

One of the key learning outcomes for me this year is the importance of starting with a clear vision as a tool to guide the enterprise development. Over the course of the year we worked on different projects, pivoted several times with some projects and experienced moments when there wasn't a clear path we should take next. Having a clear vision of what we wanted to achieve from the outset would have been quite valuable as we progressed through the many changes we experienced. While changes are inevitable in highly uncertain environment, such as a start-up, having a clear and consistent overarching vision that binds expectations and helps the team move forward as unit can make huge difference.

6.2 Liam – Overall Lesson Learned

An important lesson that I have taken away from this experience is the benefit of using thorough market research and customer feedback to define both products and projects early on in the development process, long before turning to prototypes and building products. More accurately defined projects and products have fewer complications in later stages of their development and are less likely to result in products that customers do not want. Getting a user-defined product specification right requires a lot of up front work, but ultimately leads to more successful ventures in the long run.

6.3 Ian – Overall Lesson Learned

Continuous customer feedback – a key learning for the team this year was the importance of maintaining active relationships with our prospective customers. The process of market validation does not stop after the initial contact. We learnt that it is important to involve the prospective customer within the product development process. We were able to make iterative adjustments to our prototype and overall business strategy after conferring with customers and gaining further feedback. We also found that building this type of relationship with a customer would encourage them to become invested in the success of the product.

6.4 Oliver – Overall Lesson Learned

In order to successfully commercialise ongoing research projects, interdisciplinary MATE teams require strong support and direction from the research team to compensate for a lack of internal domain knowledge. Alternatively, in order to build

experience of entrepreneurship through startup enterprises and resultant constructive failures, teams need complete autonomy and freedom to develop opportunities they have identified themselves and are therefore hopefully able to generate momentum and belief in the value of the venture. Either way it must be understood and accepted that academic research and commercial enterprises do not always share common objectives. Therefore, commercialisation teams must be prepared to pivot, adapt and occasionally walk away from projects as they search for the elusive viable business model.

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